THE PRINCIPLES AND PRACTICE OF FEEDING FARM ANIMALS

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PREFACE TO SECOND EDITION

THE popular demand for this book has necessitated the printing of a new edition, and this has afforded the authors the opportunity of making some corrections and incorporating new matter. The impact of war conditions on feeding practice has led to the introduction into farm rations of substitutes not normally used for stock feeding and in the restriction in the use of some foods commonly used for farm livestock. These changes in feeding practice have been incorporated partly in the main text of the book, but mainly in the chapter on "Feeding in Wartime."

PREFACE TO THIRD EDITION

WITH the change from war to peace, consideration has been given to the question of abolishing the chapter on "Feeding in Wartime" and incorporating material of permanent value in the body of the book. Unfortunately, although the war is finished, the wartime stringency on the use of feeding stuffs still persists, and it is anticipated that the rationing of feeding stuffs, coupled with the use of substitutes, will remain in force for some time yet. In view of this probability, it has been decided to retain the chapter on feeding in wartime in its present form. The authors express their thanks to readers who have called attention to errors in the tables, which errors have now been corrected.

14th December 1945.

PREFACE

NO one can be a successful breeder or keeper of livestock unless his stock are fed properly; this involves the judicious selection of the appropriate feeding-stuffs, feeding them in the correct proportions and weights, and varying the ingredients used according to supplies and costs.

During the present century the older practice of feeding farm livestock on foods produced largely on the farm, and keeping the stock under natural conditions of management, has given way to methods of feeding in which by-products of industry are largely used, and the stock are, in many cases, kept under artificial conditions of management. As the result of these changes in feeding and management, livestock owners found that rations, which in the past gave successful results, often proved inadequate under modern conditions, and farmers, in consequence, have shown an increasing tendency to consult experts on feeding when they wished to formulate rations including unfamiliar feeding-stuffs, or when the stock were kept under artificial conditions of management.

In this book, the authors have attempted to meet this need, by explaining in simple terms the principles of nutrition and the application of these principles to the feeding of farm livestock. In so doing, they have further endeavoured to maintain a proper balance between the natural enthusiasms of science and the practical points of good husbandry; none too easy a task, since it is generally admitted that the scientist and the husbandman have always proved uneasy bedfellows.

While primarily intended for the use of students who wish to learn how to compute rations for the various classes of stock, it is hoped that practising farmers will find much to interest them in this book, for a number of proved rations are given in the text, and the principles of feeding management summed up under the general term "good husbandry" are fully explained.

Throughout this book it is necessary to consider feeding-stuffs of average composition unless specifically designated, but it must be fully appreciated that the composition of a food is very materially affected by the nutrients available in the soil on which it has

been grown. This is clearly exemplified in the case of phosphate-deficient areas of the world where grass and hay are deficient; since these foods form the staple diet of the stock the latter suffer severely from phosphate deficiencies. In such countries wonderful results are obtained by manuring the land with phosphates and thereby improving the quality of the grass. It is also well known that roots grown in this country have not a constant food value, this is most clearly illustrated by quoting from the sugar-beet crop—under Fenland conditions the sugar content of beet is often 3 or 4 % lower than that of sugar beet grown on the ordinary soils in the neighbouring localities. It must be equally recognized that all feeding standards mentioned are also averages and hence they will not apply to all stock under all conditions; the standards are merely rough guides. It is not intended that they should be given dogmatically, but since it is necessary to give concrete examples worked out for the sake of keen students of nutrition it is necessary to appear to be dogmatic. It is well known that rations will vary with districts, but as far as possible the cases given are general rations and not rations for special districts.

The book was written to serve as a guide to feeding during times of peace, but realizing that war creates special problems in the feeding of livestock, an attempt has been made to deal with these problems in a special chapter on feeding in wartime. It is hoped that this chapter may prove of service to farmers faced in the present emergency with the problem of feeding their livestock on war emergency rations.

The authors wish to express their gratitude to various members of the staff of the School of Agriculture, Cambridge, in particular to—Professor F. L. Engledow, Mr. W. S. Mansfield and Dr. H. G. Sanders for helpful criticism and advice, and to Mr. K. E. Hunt for help in the computation of the data given in the tables in the Appendix.

Their thanks are also due to the Controller of H.M. Stationery Office for permission to reproduce certain tables based on those appearing in Ministry of Agriculture and Fisheries Bulletins Nos. 42 and 48.

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SECTION A. THEORETICAL CONSIDERATIONS

CHAPTER I

CHEMICAL COMPOSITION OF FEEDING-STUFFS AND ANIMALS

FOOD is the fuel that keeps the fire of life burning. It is the purpose of this section of the book to show what a food is, how it works, and what becomes of it. The whole industry of agriculture is directed towards producing the food of man, and the science of nutrition consequently forms a very important branch of the scientific principles of agriculture. In the report of the Milk Costings Committee it was made very clear that 60% or more of the cost of production of milk lay in the cost of the food of the cow, and it becomes very evident that it is very easy for the margin of profits that exists in milk production to be swallowed up by inexpert or extravagant feeding.

Food of Plants and Animals.

Food is one of the necessities of life. The farmer in his practice of agriculture deals with two classes of living things, plants and animals. The food of plants consists of carbonic acid gas and comparatively simple chemical substances dissolved in water, and when the farmer manures the soil he is really providing the plants with food so that they can grow, wax fat, and yield him a bounteous return for the energy and money expended. By the patient investigations of research workers the scientific principles of manuring—in other words, of providing food for plants—have been discovered, and to what extent the application of these principles in practice has been successful will be made clear to all who read the numerous books that have been published on the subject.

The food of animals consists of plants, plant products, and, in the case of man and the carnivora, of the flesh of other animals. The story of the food of animals is therefore much more complicated than that of plants, and in attacking the problem of what the food of animals consists, research workers quickly found themselves in difficulties. In fact, the story has only become clear during the last twenty years, and even now we cannot give the complete

story, although there is sufficient known to guide us with security in feeding and caring for stock.

Nature of the Food of Animals.

In endeavouring to solve the problem two lines of attack lay open, and both these lines were followed. The first consisted in cutting open and examining with a microscope the structure of foods, plants, and animals; the second line of attack was to find out the chemical composition of the plants and animals. In the first line of attack it quickly became evident that all plants and animals, however complicated in appearance and shape, were in reality composed of certain unit particles called cells, very much in the same way as houses of various shapes and sizes are all built up out of bricks. The simplest plants and the simplest animals consist of one-celled individuals; bacteria, for instance, are examples of one-celled organisms. The kinds of plants and animals that the farmer deals with, however, consist of millions of cells all working together for their common good.

The typical living cell consists of a mass of jelly-like substance called protoplasm, surrounded in some cases by a cell wall. In the centre of the protoplasm is a darker egg-like body which is called the nucleus, and all living cells contain a nucleus. In the case of plants the cell walls develop to a great extent; in the case of animals, the cell wall rarely develops except as a thin parchment-like skin or membrane. The cell walls, or substances secreted by the living cell, give rigidity or strength to the plant or animal. In plants the cell walls are largely developed, and the wood of trees consists largely of masses of dead cell walls. In animals the hard parts, or bones, which form the skeleton largely consist of mineral substances formed from living cells, but the soft parts, such as the muscles, consist of masses of living cells.

Elements of Food Constituents.

It is therefore evident that, although a haystack and a bullock are very different things in appearance, when we come to look at them very minutely we find that they are built up from very similar materials, and we can regard both as being formed from cells and cell products. As soon as it was realized that the plant cell and the animal cell formed the key to the study of plants and animals the chemist began to analyse—that is, split up—the cell into its elementary parts. The

chemist had already discovered that the myriad substances that he had to deal with were really formed from one, two, or more of ninety-two substances, which, try all he might, he could not split into further simpler substances, although in recent years by somewhat drastic treatment the physicists have succeeded in converting one element to another. These substances he called elements, and the substances compounded of these elements he called compounds. The manures nitrate of soda and sulphate of ammonia are, for instance, compounds, both of which are common in containing an element called nitrogen, the presence of which renders these substances of value to the farmer.

On analysing the jelly-like substance called protoplasm the chemist discovered that the following elements were generally present:—hydrogen, nitrogen, oxygen, carbon, sulphur and phosphorus. The first three of these elements are gases, the others solids. In addition to these elements the chemist found that when he burnt plant or animal substances he was left with an ash. Analysis of plant ash showed the presence in the plant of the following elements:—potassium, sodium, calcium, magnesium, manganese, iron, aluminium, silica and chlorine. All these elements, except chlorine are metals. Analysis of ash from animal substances showed the presence of potassium, sodium, calcium, magnesium, iron and chlorine. Writing down the elements that are common to both plants and animals, and are therefore of importance in the feeding of animals, we find that the list is as follows:—carbon, hydrogen, oxygen, nitrogen, chlorine, sulphur, phosphorus, potassium, sodium, calcium, magnesium and iron. In addition to these elements, small quantities of zinc, boron, copper, iodine, cobalt, etc., are often present, and these elements, called "trace" elements, are also of importance. Except in the case of oxygen, and, to a certain extent, nitrogen, none of these elements is present in the animal body in a free or uncombined state, but is linked up or joined chemically together with others to form a large series of complex chemical compounds.

The Composition of Feeding-Stuffs.

It is apparent from the foregoing that plant and animal materials, however complex and diverse in composition and appearance, are composed of a comparatively small number of elementary substances. In studying the question further, the chemist found that all foods could be classified into three main groups according to their appearance and behaviour when submitted to chemical tests. The main

division consisted in grouping all fatty and oily substances together, all starchy and sugary substances together, and all fleshy or meat-like substances together. Some substances may be regarded as belonging almost entirely to one of these groups, others consist of an intimate mixture of two or all of these substances. For instance, mutton fat and white of egg are examples of pure fatty material and fleshy material respectively, whereas an oil seed cake such as linseed cake, contains all three of the substances above mentioned.

For the sake of convenience for reference, and owing to the faultiness of ordinary phraseology, the chemist called these three main groups proteins, fats and carbohydrates. The feeding value of feeding-stuffs depends upon the presence of these substances, and it is for this reason that the Feeding Stuffs Act insists on the declaration of the percentage of protein and oil in a feeding-stuff.

Accessory food substances.

Beside the three main groups of food substances already mentioned, there are two other groups that play an important part in nutrition, since unless these are also present, the animal is unable profitably to utilize the proteins, fats and carbohydrates present in the food it eats. These two groups are mineral substances and vitamins.

Mineral Substances.

The animal requires relatively large quantities of sodium, phosphorus, calcium and chlorine elements that are not always abundant in feeding-stuffs. It is for this reason that stock feeders supply their stock with rock salt, and in certain cases precipitated bone phosphate, and why it is that wild animals make periodic visits to "salt licks." The animal normally obtains its mineral requirements from the plant foods it eats, but if the soil happens to be deficient in mineral salts, the herbage growing in this soil will also be lacking. Indeed, this lack of mineral in the herbage in certain districts of the world gives rise to definite disorders of malnutrition in stock raised in such areas. Thus in certain parts of Africa a disease known as Styfsiekte has been shown to be due to lack of phosphorus in the herbage grown on this phosphorus-deficient soil, and in certain parts of New Zealand a disease is known to affect sheep grazed on herbage derived from an iron-deficient area. Where the soil is deficient in mineral constituents such as phosphorus or lime, it is absolutely essential to supply the stock with compounds of lime or phosphorus, unless the deficiency in the soil is corrected by the application of

suitable manures. We thus see that the health and well-being of stock on certain types of land may be, to a large extent, dependent upon the extent to which any mineral deficiencies are corrected by the intelligent application of suitable manures to the land, a somewhat startling but nevertheless interesting fact for stock-feeders.

Vitamins.

The existence and importance of vitamins was first realized when it was found impossible to rear animals on specially purified diets. Animals fed on some diets, although containing adequate amounts of proteins, fats, carbohydrates and mineral substances, failed to thrive and sooner or later died. There was, therefore, present in diets constructed from naturally occurring feeding-stuffs, a factor or factors essential for growth and health, and it was evident that in the absence of these factors the animal was unable to utilize the proteins, fats, carbohydrates and mineral substances present in its food supply. Since the amounts of these necessary food substances required to ensure normal health and growth are very small in quantity, whereas the amounts of proteins, fat and carbohydrate are comparatively large, the feeding value of a food is measured by the amounts of protein, fat and carbohydrate it contains. At the same time, the necessity of ensuring that the ration of mixed feeding-stuffs fed to an animal contains adequate amounts of vitamins and mineral salts is recognized, and care is taken to provide for this when rations are formulated.

CHAPTER II

THE FATE OF FOOD IN THE ANIMAL

Main Constituents of Foods.

SINCE proteins, fats and carbohydrates form the three main chemical groups of substances of feeding value, it will be useful here to summarize the main characteristics of these groups of substances.

Proteins (formerly called albuminoids and proteids) are compounded of the elements carbon, hydrogen, oxygen, nitrogen and generally sulphur or phosphorus in varying proportions, and are widely distributed throughout the plant and animal worlds. Some of these proteins are soluble in water, others in alcohol, and their value to the animal depends largely on the relation they bear to the composition of the animal proteins. Cannibalism, in fact, is the most economical way of living; a dog fed on dog flesh requiring less protein to keep it alive than if fed on any other material. The chief value of proteins is their value as flesh formers. For this reason the young animal requires a considerable proportion of protein in its diet for growth purposes, while the adult animal requires a certain daily amount to replace worn-out tissue. Proteins also have a special value in the eyes of the farmers, since the animal residues from protein-feeding are specific plant foods. A protein-rich cake, therefore, serves a double purpose: it feeds the animal and the dung derived from it feeds the plant.

Chemical Composition.

From the chemical standpoint all proteins are considered as being built up of substances called amino-acids, all intimately linked together. It is upon the nature and proportions of these amino-acids present in a protein that its nutritive value really depends. To use a metaphor, a protein is a house, the bricks of which are the amino-acids.

Fats are familiar to all and hardly require a definition. They are all compounded of the elements carbon, hydrogen and oxygen, and by treatment with soda can be split up into a fatty acid compound

and glycerin. Ordinary soap is a fatty acid compound and is obtained from fat by this means, the glycerin obtained at the same time being used for cosmetics in peace-time and explosives in war, both being equally effective in disturbing the peace of man. Fat forms the reserve food material in the body, and a certain proportion in the diet is essential for the well-being of the animals. It is important here to realize that the common term "oil" is often applied to two classes of substances, one of which is useful for feeding, the other is valueless. Thus linseed oil is a useful feeding material; paraffin oil is useless.

Carbohydrates form a very large group of substances, very diverse in appearance, and include such materials as starch, sugar and cellulose or woody fibre. They are compounded of the same three elements as fats, but the amounts present are in stated definite proportions, and the name carbohydrates is based on the fact that the hydrogen and oxygen are always present in the same proportions as in water. Their value to the farm animal is of two distinct kinds: the woody fibre helps to form bulk, so essential to the herbivorous animal, and the starchy materials and sugars form elements which enable the animal to move, work and perform its various functions. The work of Lawes and Gilbert established many years ago the fact that starch may be converted into fat in the animal. Starchy and sugary materials are therefore of great value in the diet of a fattening animal.

We have seen that the value of a feeding-stuff depends upon the amounts of protein, fat and carbohydrates present, and that feeding-stuffs contain admixtures of these three classes of food-stuffs. From the standpoint of the feeder it is convenient to divide feeding-stuffs into various groups based partly on their relative richness in these substances and partly on their origin. Such a classification from a scientific standpoint is unsatisfactory, but from a feeder's standpoint is useful in that it groups all feeding-stuffs of a like nature together, and so enables him to substitute one feeding-stuff for another with a reasonable hope that such substitution will not result in untoward events. Classifying according to composition and physical characters, all known animal feeding-stuffs would fall into three groups.

Classification of Feeding-stuffs.

I. *Succulent or watery feeding-stuffs.*
  (1) Roots and tubers—mangolds, potatoes, swedes, etc.
  (2) Green fodders—grasses, clovers, vetches, cabbage, rape, etc.

II. *Bulky dry fodders or roughages.*
 (1) Hay.
 (2) Leguminous straw—bean and pea.
 (3) Cereal straw, chaff and husks, etc.

III. *Concentrated foods.*
 (1) Seeds—barley, oats, linseed, beans, etc.
 (2) Oil cakes—linseed, coconut, palm kernel, earthnut, etc.
 (3) Cereal by-products—brewers' grains, bran, middlings, etc.
 (4) Animal products—meat meal, fish meal, milk, etc.

As a general rule, the chemical composition roughly follows the classification outlined above. Feeding-stuffs falling in Group I generally contain less than one-twentieth their weight of digestible protein and less than one-fifth their weight of digestible carbohydrate; feeding-stuffs in Group II contain approximately the same amount of digestible protein, but approximately double the carbohydrate. In Group III, as a general rule, the feeding-stuff contains either more than 12% digestible protein or more than 50% digestible carbohydrate, and in Group III (4) the product mentioned contains a very high proportion of digestible matter.

Glancing at the classification above it will be seen that it would serve also as a classification of foods intended for human consumption, except with regard to Group II. "Chewing straw" in man is a distraction, not a serious form of taking food. All the feeding-stuffs in this group are bulky and dry in nature, and contain considerable quantities of woody fibrous material which are entirely unsuited to the human digestive apparatus. The capacity to deal with these fibrous foods also varies considerably among the farm animals. It becomes, therefore, a matter of interest and importance to discover the cause of this varying capacity.

The Composition of the Animal.

In the previous sections an attempt has been made to show how the chemical composition of feeding-stuffs is correlated with the composition of the animal which lives on these feeding-stuffs, leaving for further discussion at a later stage the question of the importance of an adequate supply of ash or mineral ingredients and vitamins to the growing animal. With regard to farm animals, the interest of the farmer is confined to the very important problem of producing the maximum amount of edible meat with the minimum amount

of feeding material, and the solution of this problem forms one of the most important lines of future research for workers in animal nutrition.

As far back as the 'fifties Lawes and Gilbert, of the Rothamsted Experimental Research Station, had endeavoured to ascertain the change in chemical composition of animals at different ages, and in their experiments, carried out in great detail, they analysed the entire carcases of cattle, pigs and sheep, also ascertaining the amount of offal produced and the proportion of carcase to the live weight. Such experiments involve a considerable amount of laborious work, and the magnitude of the analytical work alone is sufficiently great to prevent most workers from attempting its solution. Lawes and Gilbert obtained results for a calf and a bullock in a "store," half fat, and prime fat condition. Results were obtained in addition for a lamb, a "store," half-fat, and prime fat sheep, and a pig in "store" and fat condition. The live-weight and dead-weight tables used in everyday practice are based on this work. Since that date a fair amount of work has been carried out in America, and figures have been obtained which enable us to state approximately the change in composition of animals at different ages.

Constituent Parts of an Animal.

From a rough anatomical standpoint, an animal consists of soft parts and hard parts. The hard parts consist of a bony framework which supports the animal and enables it to move, and attached to these bones are the muscles, which cause the movement. The soft parts are comprised of the internal organs, the muscles and the enveloping skin or envelope. When killed, the animal is roughly divided up into carcase, head, skin and offal, the latter consisting of the intestines or gut, liver, heart and lungs. The muscles, with the adherent fat, form the edible portion or the meat of the carcase, and a considerable proportion of the offal is also edible. Now the edible portion of the carcase consists of water, fat, protein and ash, and it becomes interesting to know what happens as the animal grows and becomes mature. From the analysis of animals at different ages, it would appear that the amount of water in a carcase is greatest at birth and lessens as the animal gets older. For instance, a calf at birth consists of 70% water, whereas a fat bullock contains 50% water. Since fat is insoluble in water, it follows that the fatter an animal, the less water there is present in the entire carcase. Thus a fat pig will contain less water than a "store" pig.

About one-twentieth of the bodies of animals consists of mineral ingredients or "ash," of which the bones form the largest proportion. The two more abundant elements present are calcium and phosphorus; potassium, magnesium and sodium also being present. Sulphur is commonly present in a combined form in the muscles, skin, horn and hair. Fat, being a "store" or reserve material, is generally present throughout the body. The reason for this is that all the organs and various parts of the body are held together and kept in place by means of a net-like supporting tissue, called on this account connective tissue; and this connective tissue nearly always contains fat-producing cells.

Development to "Store" Condition.

Combining all the results of analyses of bodies of farm animals, it is possible to give a rough story of what happens in the animal's body from birth up to maturity:

At birth, water is abundant throughout the body, the bones are in a partially developed condition, and the protein forms approximately one-fifth of the weight of the animal. There is very little fat present. Meat from such animals is watery and sappy in taste, very tender, and the bones are easily broken. As the animal grows, the bones lengthen and harden, and the muscles increase in size, until the animal reaches the "store" condition. At this stage the animal has nearly reached its full height and size. Less water will be present, the muscles will be fully developed, and the amount of fat present will depend upon the nature and amount of food the animal has been provided with during the growing stage. This fact is recognized in general practice by having what is known as the "store" period if it is not intended to fatten the beast until it has reached maturity. The food given to the animal during this "store" period is not of a nature likely to enable the animal to put on fat. Examination of the carcase of a normal twenty-one-months-old steer and a twenty-one-months-old steer fed to produce "baby" beef will illustrate the effect of feeding on the fattening capacity of an animal.

Deposition of Fat during Fattening.

After the "store" condition is reached, if a fattening ration is given, the fat is deposited in the connective tissue, the animal begins to fill out, and as the final stage is reached the fatness of the animal is even evident to the person whose interest in stock begins, and,

unfortunately, generally ends as well, when the animal is on the table in the form of a first-class joint. In the early stages of fattening, the fat is deposited under the skin, but as fattening proceeds, the fat becomes abundant so that it is deposited between the individual muscle fibres and also in the connective tissue surrounding the internal organs. It is to the deposition of the fat between the fibres of the muscles themselves that the "marbling" so prized by the butcher and consumer alike is due, and it is this "marbling" which is a contributory cause to the flavour, tenderness, and quality of the joint. At this stage the prime fat bullock will consist of nearly one-third fat, about one-half water and about one-seventh protein.

The following table gives the composition of various meat-producing animals at different ages and weights, calculated on the "empty" weight of the animal—i.e. after subtracting the weight of the contents of the stomach and intestines:

Animal	Age	Condition	Percentage Composition			
			Ash	Protein	Fat	Water
Calf	At birth		3·9	19·5	4·8	72·1
Bullock	.. ..	Thin	5·4	19·3	14·4	60·1
,,	.. ..	Half Fat	4·8	17·6	19·1	56·4
,,	.. ..	Fat	4·7	18·9	26·6	50·7
Pig	11-12 mons.	Store	2·8	14·6	24·6	58·1
,,	11-12 mons.	Fat	1·7	11·4	53·9	43·0
Sheep	1 year	Store	3·4	15·8	19·9	61·0
,,	1¼ years	Fat	3·0	13·0	37·8	46·2
,,	1¾ years	Extra Fat	3·1	11·6	48·3	37·1
Geese	9 months	Unfattened	3·9	23·0	17·4	55·7
,,	10 months	Fattened	3·3	18·7	26·4	51·6
Cockerel	14 weeks	Unfattened	4·2	19·1	9·7	66·5
,,	17 weeks	Fattened	3·6	18·7	13·9	63·1

The above table illustrates the following points: 1. As the fat of the animal increases, the water percentage decreases. 2. As the fat of the animal increases the protein percentage decreases. 3. The younger the animal, the more water in the carcase.

The following diagram (Fig. 1) illustrates graphically the difference in composition of (1) calf, (2) store bullock, (3) half-fat bullock, and (4) fat bullock.

The Digestion of Food-stuffs.

In order that the food given to farm animals may become available for use, the animal has to convert it into a soluble form so that it

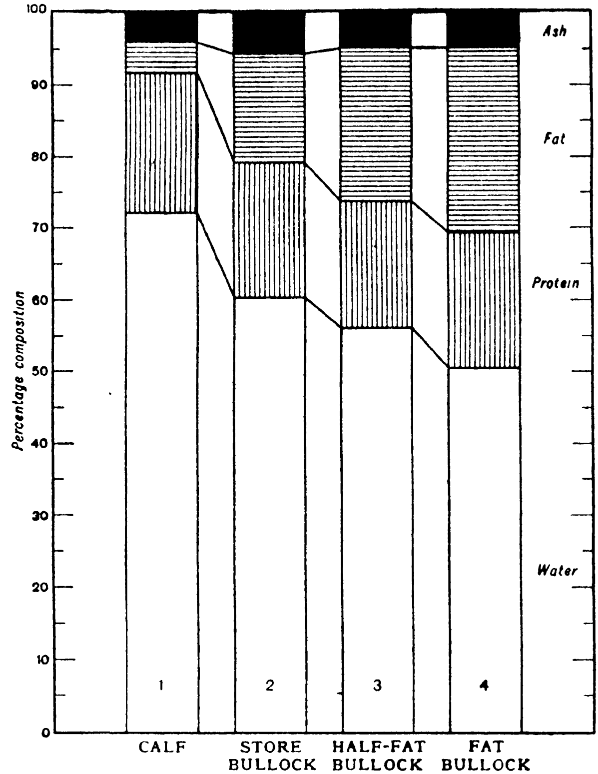


FIG. 1.

VARIATIONS IN COMPOSITION OF BODY WITH AGE

may pass through the wall of the gut. For this reason all animals are provided with a digestive system, generally referred to as the alimentary canal. The alimentary canal consists essentially of a very long tube, beginning at the mouth and ending at the anus, this tube enlarging at various portions to form characteristic compartments. We can thus distinguish a gullet, stomach, small intestines, and large intestines (see Fig. 2). The gullet passes the food from the mouth to the stomach, the stomach acts as a storehouse, and the small intestines and large intestines extract the nutritive portion of the food, the undigested residue being passed out at the anus as dung.

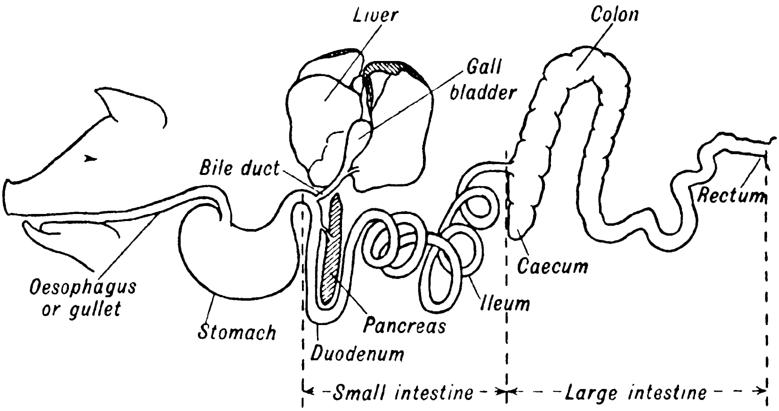


FIG. 2.—DIAGRAM OF TYPICAL DIGESTIVE SYSTEM

Stages of Digestion.

The digestion of food occurs in several stages. In the first stage the food is ground up into fine particles and mixed with the spittle or saliva. This saliva performs two functions: it moistens the food, thus enabling it to be swallowed in convenient portions, and it also contains a ferment called ptyalin, which acts on the starchy portion of the food and converts it into sugar. If a dry biscuit or wafer is chewed in the mouth for a minute or two, sufficient sugar will be developed to give it a sweet taste. The breaking-up process is carried out by the teeth, tongue and jaws working in unison, and the process is finally completed in the stomach. Food leaving the stomach is in the condition of a moist, creamy mass of fine particles. While in the stomach the food is churned up and mixed with digestive juices which are secreted or produced by the inner stomach lining itself. This lining consists of a multitude of little tube-like structures placed side by side, and the cells secrete the digestive juice which is called gastric juice. Such a collection of cells grouped together for the purpose of manufacturing a secretion is called a gland. The exit from the stomach to the intestines is guarded by a circular muscle called a sphincter muscle; this muscle, acting as a sentinel, only allows food in a finely-divided condition to pass into the intestine.

While the description just given is true for mammals, it does not hold for birds owing to the anatomical differences in this part of

the digestive tract. In the fowl, there are no teeth, and the food is stored in a pear-shaped enlargement of the lower end of the gullet known as the crop. The glands of the mouth, too, are not so active as in the mammal although there is a starch-splitting ferment present in the saliva. Indeed, the watery secretion which is found in the crop and aids in softening the food stored therein is largely derived from glands present in the walls of the gullet itself. In the pigeon, during the mating season, the crop fulfils another function, it provides the crop milk with which the adult birds feed their young. This crop milk is formed by the growth of the internal lining of the crop, and it is interesting to note that this crop milk is produced by the cock bird as well as by the hen. It is also important to realize that when a bird is in a starving condition, the first two or three portions of food swallowed do not fall into the crop but go straight on to the stomach and gizzard. The food passes from the crop or the gullet to the stomach which is differentiated into two portions, a round tubular-shaped glandular stomach (the proventriculus) and the muscular stomach (the gizzard). The glandular stomach is richly supplied with glands which secrete the gastric juice. The food only remains in the glandular stomach for a few seconds, and in its passage through receives the gastric juice poured out from the mouths of the gastric glands. The gizzard is an extremely strong muscular organ, and has a horny lining and contains grit and stones picked up by the fowl. This gizzard undergoes a series of slow rhythmical contractions and the food within it is subjected to great pressure and quickly reduced to a finely powdered mass of material. It will thus be seen that the gizzard supplies to the fowl that triturating or grinding action that in the mammal is carried out by the jaws and teeth.

The next stage is reached when the food enters the small intestine. Close to the exit from the stomach are several openings of tubes or ducts which lead to the liver and another gland called the pancreas. The liver secretes the bile or gall which is stored in the gall bladder, when present. The sheep, pig, fowl and cow possess gall bladders; the horse and pigeon do not. The pancreas, more familiarly known as the sweetbread, gives rise to a very powerful digestive juice which acts upon proteins, fats and starchy material or carbohydrates. The bile performs a very important part in the digestion of fats, and any interference with the supply of bile to the gut will lead to the appearance of undigested fat in the dung or excreta.

There is a remarkable provision whereby the pancreatic juice is supplied as it is required. The stomach contents, which are acid,

in entering the small intestine set free in the lining walls of the intestine a chemical substance called secretin, which, passing via the blood stream to the pancreas, causes an immediate flow of pancreatic juice, which thus becomes mixed with the food. By the muscular movement of the intestines the food undergoes a slow churning movement, the food mass always progressing towards the end of the gut. The digestive juices meanwhile act upon the digestible nutrients of the food, and the final products are soluble sugars, such as glucose or grape sugar, glycerin and fatty acids, amino-acids and indigestible residue.

The third stage is the absorption stage. The entire alimentary canal, and particularly the small and large intestines, are supplied with a fine network of blood vessels which lie close to the inner lining of the intestines. The sugar, glycerin and fatty acids, and amino-acids pass through the lining membrane and thin wall of the blood vessels into the blood itself. The glycerin and fatty acids, after passing through the lining membrane, are reconverted to fat, and as fine, fatty particles reach a special network of spaces and tubes called the lymphatic system. This fat finally reaches the blood stream. The undigested residue passes on and is finally excreted.

Summary of Digestive Processes.

We thus see that the process of digestion, although very complex in nature, may be put into a simple statement. Briefly stated it is as follows: The nutritive portion of a feeding-stuff consists of the protein, fat and carbohydrates it contains. In order that it may become available to the animal these substances must become soluble, so that they may pass through the inner lining of the gut to the blood stream. This is effected by the digestive juices, whose action is facilitated by the preliminary grinding of the food either by the gizzard in the case of the fowl, or in the case of the mammal by the mouth and jaws and the constant kneading by the muscular stomach and intestines. The digestive juices convert the carbohydrates into soluble sugars, the proteins into soluble amino-acids, and the fats into soluble fatty acids and glycerin. These substances are absorbed and are thus available for growth, repair and energy. The undigested residue, which appears as dung, represents the valueless portion of the feeding-stuff. If, therefore, we wish to ascertain the feeding value of any feeding-stuff it would be necessary to ascertain the amount of the feeding-stuff which appears as indigestible residue, and it is the purpose of feeding experiments to ascertain this. It is

possible to construct two feeding materials having the same chemical composition which, however, have distinctly different feeding values. The digestibility experiment enables us to distinguish between these two and to safeguard the stock feeder.

With regard to the water swallowed with the food, the larger portion of this is absorbed by the latter part of the intestines or large gut. This is evident if the inside of a rabbit is unravelled and studied. It will be found that the contents of the small intestine near the gut is liquid, and as the intestines are traced down towards the end of the gut the contents become more solid, until towards the anus the characteristic pellets of dung will be noticed.

Function of Fibre.

The fibrous portion of the food is of importance to the animal. Its function is to give bulk to the food, thus adding to the animal's feeling of contentment. The digestive juices secreted by the animal have no dissolving effect upon the fibrous material, as far as we are aware, but this material is acted upon partly by ferments present in the food itself and partly by the action of innumerable bacteria present in the alimentary canal.

Relation Between Food Consumption and Structure of Digestive Tracts of Stock.

The feeding of farm animals is so closely correlated with the differences in structure of the digestive tracts of these animals, that practical precautions in the feeding of stock must be based on these structural differences. All farm animals are herbivorous in type and can be divided into two classes—i.e. those that chew the cud, called ruminants, and those that do not. The sheep, cow and bullock are examples of ruminants, the pig, horse and fowl are non-ruminants.

Digestive System of Ruminants.

The ruminants differ chiefly from the non-ruminants in having a very complex stomach consisting of four compartments, the rumen or paunch, the reticulum or honeycomb bag, the omasum or psalterium and the abomasum or true stomach. The paunch is very large and acts as a store for the grass and other foods which are hastily swallowed by the cow or sheep. The honeycomb bag acts as a store for water. Food from the paunch is thrown up again in small

wads into the mouth and is there carefully chewed and reswallowed. When swallowed for the second time the opening into the paunch and honeycomb bag is closed by a muscular groove, and the masticated food passes over this groove into the third stomach or omasum. The omasum is a muscular stomach thrown up into folds like the leaves of a book, and the food passes through between these leaves. The latter are supplied with muscular bands which contract and expand alternately, and the food passing between them is submitted to a rubbing action, so that when it reaches the true stomach or abomasum, the food is in a finely divided condition.

The digestive juices are secreted in the abomasum and small intestine, and digestion goes on on the same general plan as explained in a preceding section. The small and large intestines in ruminants are comparatively simple in structure. In the non-ruminants the stomach is simple in structure and resembles a pear-shaped bag. The small and large intestines are rather more complex than in the ruminants, particularly so in the horse. The complicated stomachs of the cow and sheep enable these animals to deal with comparatively rough, fibrous foods. The horse, although simple stomached, has a very complicated intestine, which also enables it to deal with coarse fibrous foods. The pig, on the other hand, has both a simple stomach and intestines, and cannot therefore deal satisfactorily with bulky fibrous foods.

The large intestine of the horse is divided into three distinct portions called the cæcum, the colon and the rectum. The cæcum resembles a bag closed at both ends, the entrances from the small intestine and the colon being placed close together. An internal longitudinal fold prevents the food from passing direct from the small intestine into the colon. The colon is a wide U-shaped tube about 8 in. wide, narrowing to 4 in. at the bend of the U. Owing to its peculiar shape the passage through this bend is easily closed if gas accumulates in the colon. The malady "colic" is due to obstruction of this passage through dietetic errors setting up fermentation in the colon.

The diagrammatic drawings in Fig. 3 illustrate the varying types of structure of the digestive tracts of the horse, sheep, pig, fowl and cow or bullock, and should be studied in conjunction with the preceding paragraphs.

Comparison of Digestive Tracts.

The cubic capacity of the digestive tract of the pig is 6 gals., of the sheep 8 gal., of the horse 46 gal. and of the cow or bullock

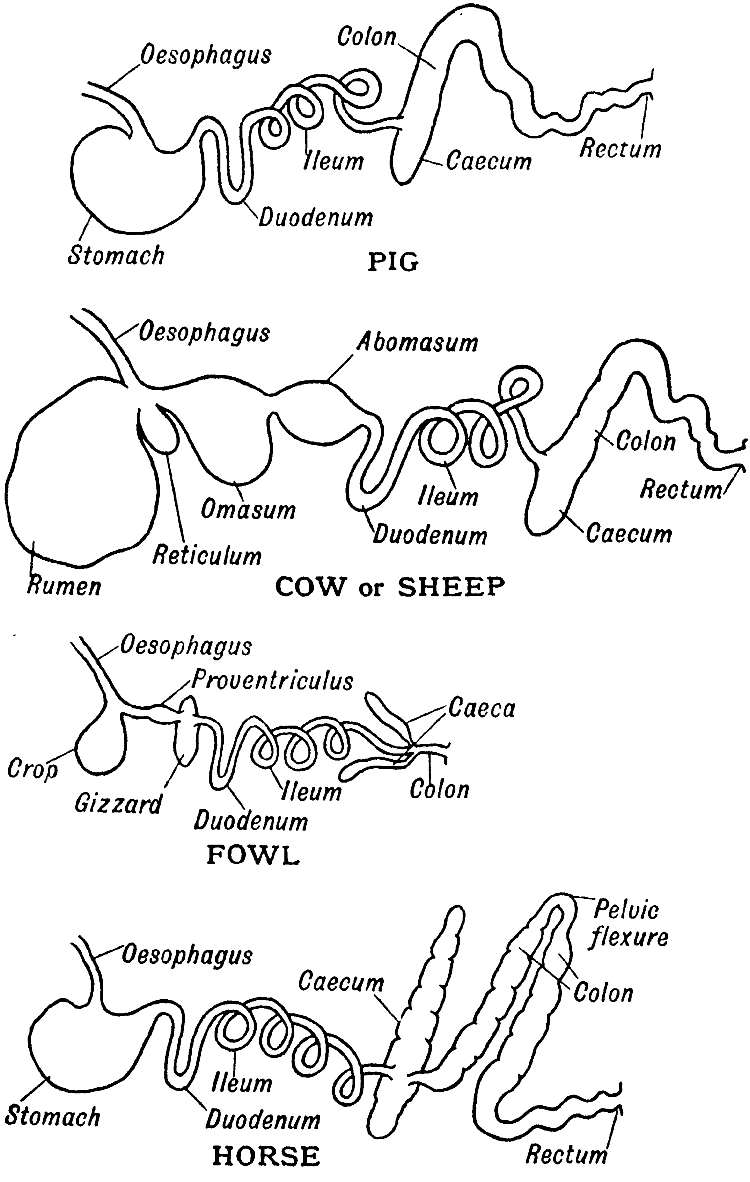


FIG. 3.

DIGESTIVE TRACT OF PIG, COW OR SHEEP, FOWL AND HORSE

65 gal. The capacity of the stomach of the pig is 2 gal., the sheep 5 gal., the horse 4 gal. and the cow 43 gal. The capacity of the small intestine of the horse is 12 gal. and the cow 14 gal., that of the pig and sheep being 2 gal. The capacity of the large intestine of the cow is 8 gal., that of the horse 30 gal., while the pig and

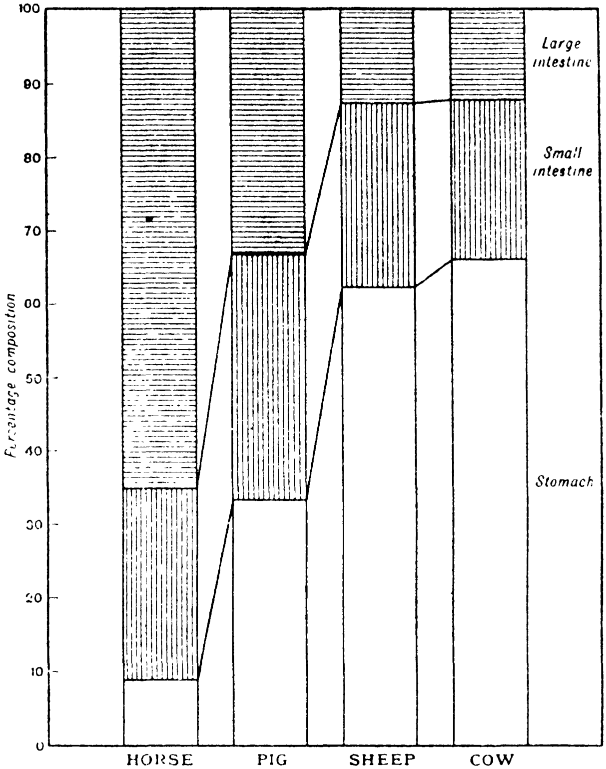


FIG. 4.—CAPACITIES OF DIGESTIVE TRACTS

sheep are respectively 2 gal. and 1 gal. Translating these measures into percentages of the total capacity of the digestive tract, we find that the horse possesses the smallest stomach and the pig the next smallest, while the sheep and the cow have very large stomachs. On the other hand, the relative size of the large intestines is in the inverse ratio to the size of stomach. Thus the horse has relatively the largest large intestine, followed in due order by the pig, the sheep, and the cow. This is

shown in Fig. 4, the length of each column representing the total capacity of the digestive tract in each case.

Fig. 5 represents in scale the actual capacities of the stomach, small intestine and large intestine of the pig, the sheep, the cow and the horse.

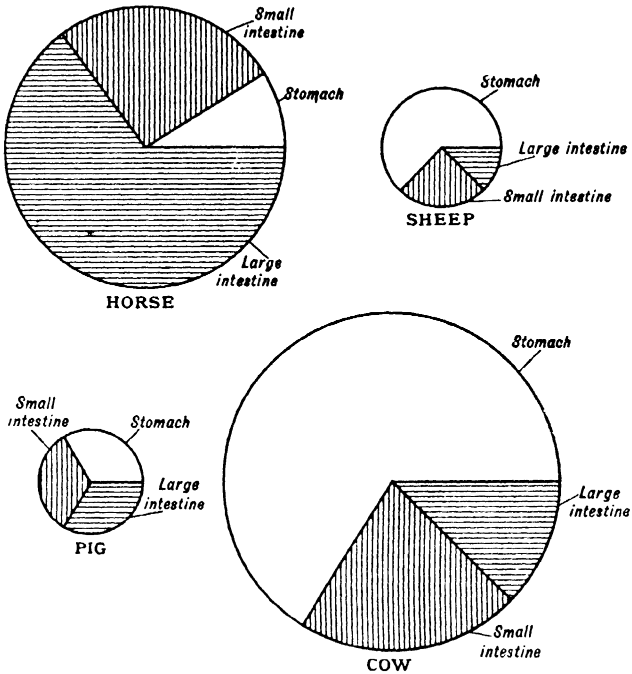


FIG. 5.—RELATIVE CAPACITIES OF DIGESTIVE TRACTS OF PIG, SHEEP, HORSE AND COW

In the case of the fowl, the capacity of the digestive tract is 8½ fluid ozs. The crop, which we have already noted acts as a food storage depot, has a capacity of 4½ fluid ozs., the gizzard holds ½ fluid oz. and the intestines 3½ fluid ozs.

Practical Applications.

The lessons to be drawn from our study of the structure of the digestive tracts of the horse, cow, sheep, fowl and pig are as follows:

The Horse.—Owing to its comparatively small stomach the horse is a careful and dainty feeder, but owing to its complicated large

intestine the horse will be able to deal with coarse and bulky fodders if we wish to feed them. The actual capacity of the digestive tract is, however, only about two-thirds that of the cow. If, therefore, a horse is resting, coarse fodders, such as hay and straw, will form the bulk of the diet. If working the horse, these bulky fodders must be replaced with more concentrated foods, such as oats, bran and beans, and if severe work is expected, the bulky fodder fed will consist of the best hay only. Two other points arise in feeding horses. The gullet is narrow and constricted at the entrance to the stomach, and this renders it almost impossible for the horse to vomit up food when once swallowed. This fact, coupled with the liability to "colic" already mentioned, renders imperative the necessity of care in feeding horses at all times.

The Pig.—The pig has but a small digestive tract and is unprovided with any very adequate means of dealing with coarse fodders. The diet of the pig should therefore consist of nutritious concentrated foods, such as cereal grains, cakes and meals, supplemented with a little green fodder or succulent roots. It will be obvious that silage, which will be suitable for the store pig, should not bulk largely in the diet of a fattening pig.

The Sheep and Cow.—The structure of the digestive tracts of the sheep and cow renders these animals peculiarly suited for dealing with coarse fodders. The main bulk of these animals' food should consist of hay and straw or green fodder and roots, plus concentrated foods when fattening off and when producing milk.

The Fowl.—The fowl has a comparatively simple digestive tract, and although the gizzard enables it to cope to a certain extent with fibrous foods, its capacity is such that it cannot utilize bulky fodders. Its diet therefore should consist of cereal grains and meal, with a modicum of green foods and roots. During fattening, the diet should preferably consist of finely ground foods.

Digestibility of Feeding-stuffs.

It has already been shown that the only portion of a feeding-stuff that is of value to the animal is that portion which diffuses through the wall of the gut into the blood stream. Thus, during the time which elapses between a meal and the excretion of the undigested residues, the digestible protein, fat and carbohydrate are gradually being absorbed by the gut and disappear into the blood stream. If we wish to obtain the feeding value of a feeding-stuff we must find out what proportion of the protein fat and carbohydrate is absorbed

in this manner. This is important, since we can conceivably have two feeding-stuffs containing exactly the same proportion of protein, fat and carbohydrate, as ascertained by chemical analysis, differing widely, however, in the amounts of digestible protein, fat and carbohydrate. By ascertaining the amounts of *digestible* substances present we can distinguish between these two feeding-stuffs, and say which is the better feeding-stuff of the two. It is for this reason that the information required by the Fertiliser and Feeding-Stuffs Act gives very little help to the feeder in assessing the value of a feeding-stuff, *unless* the nature of the feeding-stuff is also given.

How are the digestible nutrients in a feeding-stuff ascertained, and how are they expressed? An actual description of an experiment will indicate the method used. Suppose the feeding value of a sample of meadow hay is required. The experimenter may use either a sheep, a horse, or a bullock for the experiment. Strictly speaking, the final values obtained will differ according to the type of animal used, but the differences obtained between sheep, horses and cows or bullocks are not sufficiently serious to demand a separate table of digestibilities for these classes of stock. As a general rule a sheep is chosen owing to convenience of handling and owing to the fact that large quantities of food are not required. The amount of digestible proteins, fat and carbohydrates (called digestible nutrients) are ascertained by analysing the food given to the animal, analysing the dung produced from this food, and subtracting one from the other. The difference gives the amounts of digestible nutrients which have apparently disappeared during the passage of the food through the digestive tract.

How Digestibility of Food is Determined.

For the purpose of the experiment the sheep wears special light harness that renders the collection of the dung and the urine easy, and during the experiment the animal is kept in a special cage containing a food trough and a water trough, so arranged that the food and water are not spilt or wasted. The sheep is then fed on the chaffed hay, a measured amount being fed morning and evening. Owing to the fact that it takes two or three days for the food to pass through the animal, a preliminary feeding period of four or five days is always adopted and the dung collected in the apparatus during this period is ignored, as most of it really belongs to the food given before the experiment commenced. In order to act as a check, a little cotton cake is sometimes fed to the sheep the day before the experiment commenced, and as the hard shell is easily recognized

in the dung, it is always possible to ascertain with fair accuracy when the dung produced from the meadow hay begins to appear.

After the preliminary period is finished, for the next twelve days the dung is collected, weighed and analysed, after which the sheep goes on to ordinary food, the harness is removed, and the animal regains its freedom. Usually two sheep are used at a time, and it is surprising how docile and quiet the animals become, and how little they appear to miss their freedom. As a general rule, while under experiment, the sheep gains in weight. After the somewhat tedious series of chemical analyses of the hay and the dung are finished, a balance-sheet somewhat as follows is arrived at:

Hay fed during experiment, 12,000 grams.
Dung produced, 7,000 grams.

AVERAGE CHEMICAL COMPOSITION OF HAY AND DUNG

	Water	Protein	Fat	Soluble Carbo-hydrates	Fibre	Ash
Hay	14·3	9·7	2·5	41·0	26·3	6·2
Dung	39·4	7·4	2·6	26·2	19·4	6·0

RESULTS OF THE EXPERIMENT

	Protein	Oil	Carbo-hydrates	Fibre	Ash
In food	1164g.	300g.	4920g.	3156g.	744g.
In dung	518g.	182g.	1834g.	1358g.	420g.
Difference = Amt. digested	646g.	118g.	3086g.	1798g.	324g.

Therefore 100 lb. meadow hay contain the following digestible nutrients: Protein, 5·4 lb.; oil, 1·0 lb.; carbohydrates, 25·7 lb.; fibre, 15·0 lb.

From the above figures the following table is constructed:

Substance	Composition % as shown by analysis						Digestible Nutrients			
	Dry Matter	Protein	Oil	Sol. Carbs.	Fibre	Ash	Crude Protein	Oil	Sol. Carbs.	Fibre
Meadow hay (good)	85·7	9·7	2·5	41·0	26·3	6·2	5·4	1·0	25·7	15·0

The digestible nutrients of all the commonly used feeding-stuffs have been estimated by similar experiments to that described above, and as a result of this, tables are available which can be referred to by anyone wishing to ascertain exactly how much of a feeding-stuff is of value when fed to an animal.

The Nutritive or Albuminoid Ratio.

One other matter of importance arises in connection with the digestibility of a feeding-stuff, and that is the relationship between the amount of digestible crude protein present and the fat-producing constituents—i.e. the digestible carbohydrates, fibre and oil present. From experiments it has been shown that in feeding a ration to stock it is desirable to maintain, if possible, a certain balance between the digestible protein and other digestible non-protein substances. If an excess of starchy material is fed, digestive disturbances arise, and the animal does not obtain the full value from the feeding-stuff given to it. On the other hand, if excessive protein is given, a large amount of work is thrown on the kidneys, and although the excess protein given may aid in the fattening process, particularly in the young, growing animal, it adds unnecessarily to the cost of fattening. In order to ascertain this relationship, the ratio between the digestible protein and the digestible non-protein substances is obtained by the following formula:

$$\text{Nutritive ratio} = \frac{(\text{Digestible carbohydrates} + \text{digest: fibre}) + (\text{digest. oil} \times 2{\cdot}3)}{\text{Digestible crude protein}}$$

The oil is multiplied by 2·3 because it has been found by experiment that 1 lb. of digestible oil is equivalent to approximately 2·3 lb. of digestible carbohydrate.

Taking, as an example, the digestible nutrients of the meadow hay already given, we get the following result:

$$\text{Nutritive ratio of meadow hay} = \frac{(25{\cdot}7 + 15{\cdot}0) \times (1{\cdot}0 \times 2{\cdot}3)}{5{\cdot}4} = \frac{40{\cdot}7 + 2{\cdot}3}{5{\cdot}4} = \frac{43{\cdot}0}{5{\cdot}4} = 8$$

The nutritive ratio of meadow hay is, therefore, 1 : 8—i.e. one part of digestible protein to every eight parts carbohydrate equivalent.

Nutritive Ratio of Ration.

It has now been shown how to arrive at the nutritive or albuminoid ratio of a single feeding-stuff, and it was briefly explained why it

was necessary to know approximately the nutritive ratio of a ration for livestock. As we have seen, the nutritive ratio gives us the quantitative relationship between the respective amounts of digestible protein and non-protein substances present in a feeding-stuff. For young, growing animals a ratio of 1:4 is generally advocated, and as the animal reaches maturity the nutritive ratio of the ration is gradually widened to 1:6 or more. The adult animal can be maintained in store condition on a ration whose nutritive ratio is as wide as 1:10. There is, however, no need to keep rigidly to a fixed nutritive ratio for any particular class of stock, the object of ascertaining the nutritive ratio of a feeding ration is to make sure that it lies between 1:4 and 1:10. A ration whose ratio is outside these limits is an "unbalanced" ration, and is not suitable for feeding to stock.

How, then, can we find the nutritive ratio of a ration, given the nutritive ratios of the single feeding-stuffs and the digestible nutrients?

This apparently simple problem appears to have confused quite a lot of people, and erroneous methods are sometimes given for ascertaining the nutritive ratio of a ration. The method which follows is a practical one, and has the merit of simplicity and accuracy. It will be best, perhaps, to take a concrete example to explain the method. A farmer, say, proposes to feed the following ration to his bullocks as follows: Mangolds, 70 lb.; oat straw, 10 lb.; meadow hay, 10 lb.; decorticated earthnut cake, 3 lb.; linseed cake, 2 lb.

From a table of analysis we obtain the following facts:

	Digestible Protein %	Nutritive Ratio
Mangolds	0·7	1:11
Oat Straw	1·0	1:39
Meadow Hay	5·4	1:8
Decorticated earthnut cake	42·0	1:1
Linseed cake	25·3	1:2

In order to find the nutritive ratio of the above ration we proceed as follows: taking each feeding-stuff in turn we first find the amount of digestible protein by multiplying the pounds of feeding-stuff in the ration by the percentage of digestible protein, and dividing by 100. Thus, 70 lb. mangolds contain

$$\frac{70 \times \cdot 7}{100} \text{ lb. digestible protein} = \cdot 49 \text{ lb.}$$

The figure thus obtained is then multiplied by the nutritive ratio, and this gives us the digestible carbohydrate equivalent present. Thus $\cdot 49 \times 11 = 5\cdot 39$.

This process is followed out for all the remaining feeding-stuffs in the ration and put out in two columns as below:

	Digestible Protein	Digest. Carb. Equivalent
70 lb. mangolds contain	·49	5·39
10 lb. oat straw contain	·10	3·90
10 lb. meadow hay contain	·54	4·32
3 lb. decorticated earthnut cake contain	1·26	1·26
2 lb. linseed cake contain	·506	1·012
	2·896	15·882

The two columns are then added up as above and the second column divided by the first. This gives the nutritive ratio of the ration.

Thus $\frac{15 \cdot 882}{2 \cdot 896} = 5 \cdot 5$ approximately. Therefore the nutritive ratio is 1 : 5·5.

A ration of this nature would give the bullocks more than sufficient protein for their needs, and would actually be a wasteful ration in this respect. In practice, the decorticated earthnut cake would be probably replaced by maize meal.

The reader is recommended to work out the nutritive ratio of the actual rations used by him, obtaining the necessary facts from the tables in the Appendix.

Progress of Digested Food-stuffs.

In a previous section we have found that the only portions of a ration that are of value to the animal, apart from salts, vitamins and water, are the digestible protein, fat and carbohydrate. It becomes of interest to know exactly what happens to these materials, and to find out what part they play in the animal economy. It would make the story much too long to attempt to go into any detail, and it is proposed, therefore, to describe shortly the history of each in turn.

The *digestible protein*, we remember, reached the blood stream in the form of soluble products called amino-acids. The blood stream carried these all over the body, and the subsequent history is as follows: these amino-acids may either be built up again to form body protein—that is, flesh and muscle—or they may be broken down and excreted from the body. In this case the nitrogenous portion is eliminated in the form of urea, ammonium salts, and uric acid, these substances appearing in the liquid excreta (i.e. the urine). The rest

of the protein is used for the formation of fat or to supply energy or work. Since the nitrogenous portion of the protein is useless for the performance of work, it is a wasteful procedure to feed protein to animals for this purpose.

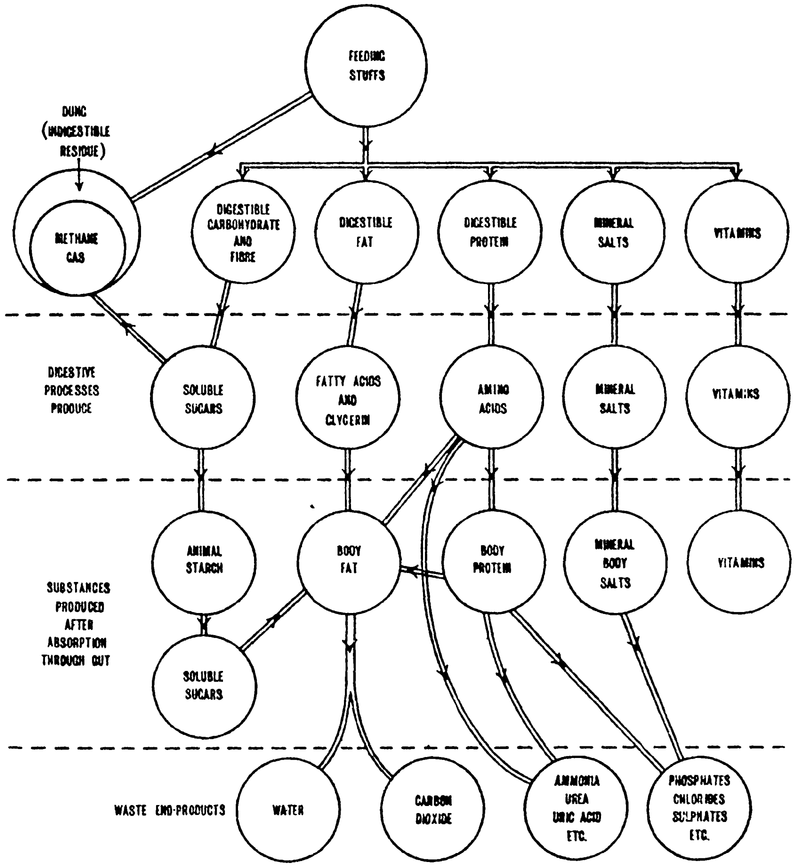


FIG. 6.—HISTORY AND FATE OF FEEDING-STUFFS

The *digestible fat* is split up by the digestive process into fatty acids and glycerin, which become joined together to form fats once more, and in this condition reach the blood stream. There is an approximately constant proportion of fat in the blood; when in excess, the extra fat is taken up by the storage tissues and deposited between

the muscles and under the skin. The reverse process occurs when the blood becomes poor in fat. Fat consequently acts as a reserve store of work, and it is the fat that provides the necessary food to keep the animal machine in good working order. In the final breakdown of fats water and carbonic acid gas are produced, and chiefly as such are eliminated from the body. The CO_2 is eliminated mainly from the lungs, the water is eliminated in the urine, from the lungs and from the skin.

The *carbohydrates* or starchy materials are absorbed chiefly as soluble sugars. During the processes of digestion, particularly in ruminant animals, some of the carbohydrate material undergoes attack by bacteria leading to the production of gases such as methane, which gases are passed out with the dung as indigestible residue. The sugars absorbed through the gut are carried in the blood stream to the liver and are converted there into animal starch (glycogen). Glycogen is also present in the muscles. This store of starch is also a reserve material and serves to keep the amount of sugar in the blood approximately constant. The sugar in the blood is used up to provide the energy for the work done by the body, and is also built up into a more stable food reserve, i.e. fat. When finally broken down, the end products, as in the case of the body fat, are carbonic acid gas and water.

In order to make the above explanatioh as clear as possible the diagram (Fig. 6) has been constructed. It will be seen from this that fat may be produced in the body from any of the three principal food-stuffs, i.e. proteins, fats and carbohydrates—but that for the formation of flesh protein must be supplied. These are the two important practical points that all feeders should bear in mind in the construction of rations.

CHAPTER III

THE QUALITATIVE OR BIOLOGICAL VALUES OF FEEDING-STUFFS

Warmth and Its Meaning.

IT must be remembered that the digestible nutrients of feeding-stuffs when used for the purpose of work are broken down to water and carbonic acid gas, together with any nitrogenous residues, such as urea, in the case of proteins. In this breakdown the nutrients undergo a series of chemical changes called oxidations, changes in which the oxygen of the air (breathed in through the lungs) plays an important part. The burning of coal or coke in a grate is an example of oxidation, and, just as coal when oxidized gives out heat, so in the same way, when the digestible nutrients are oxidized, heat is given off. On a cold day, when anybody wishes to get warm, he runs about or walks sharply. These movements accelerate these breakdown changes and heat is generated. This heat is distributed over the body by means of the blood, which acts very much like a hot-water pipe system does in a house.

It is evident then, that breakdown changes going on in the body are always giving rise to heat. Now, animals can be divided into two big classes—those whose bodies assume the temperature of their surroundings, and those whose bodies remain at an approximately constant temperature. Frogs and fishes are examples of the first class (usually called cold-blooded animals), whereas men, pigs, sheep, cows, etc., are examples of the second class of animals (warm-blooded animals). There is a very good reason why it is undesirable to belong to the cold-blooded class of animals. In any chemical change the rate at which the change takes place depends upon the temperature. At a low temperature a chemical change proceeds very slowly, and as the temperature rises the velocity with which the change goes on increases. Now, life is made up of a series of such changes, and if man's temperature changed with the temperature of his surroundings he would find life very inconvenient indeed. In the winter-time he would do little else but sleep; in the summer-time he would be unusually active, and would probably be considered a general nuisance. Everyone is familiar with the fact that in the

summer-time the frog is quite a lively "gentleman," whereas in the winter he can do little else but sit at the bottom of the nearest ditch and sulk. This is just an expression of the fact that, owing to his being a cold-blooded animal, he is at the mercy of his surroundings, and cannot decide for himself how energetic he shall be at any given time.

In the case of warm-blooded animals it would also be very inconvenient if the temperature of the body varied very much from day to day, as in this case one's power to do work would also fluctuate considerably according to the amount of heat produced in the body. If the temperature of different animals is taken at different periods if will be found that the body temperature, although differing in every class of animal, remains approximately constant for the same species. Thus the normal temperature of man is 98·4 deg. F., of the horse 100·5 deg. F., of the ox 100-102 deg. F., of the sheep and pig 103 deg. F. and that of the dog 101 deg. F.

Regulating the Temperature.

How is this temperature maintained at a constant level? Through the changes going on mentioned above, heat is constantly produced, and so the body must in some way get rid of the heat it does not require. For instance, a horse at rest would reach the boiling point of water in two days if it could not get rid of the superfluous heat produced in this period. This superfluous heat is got rid of mainly through the skin in the case of animals provided with sweat glands. The over-heated blood is carried to the skin by blood-vessels, and while there, if the external temperature is lower than the body temperature, heat is given off, or radiated from the body, just as a fire radiates heat into a room.

In cold weather this loss of heat by radiation is considerable, and it is to guard against this loss that man wears thick woollen clothes. In the summer, however, the temperature of the air is often higher than that of the body and the loss of heat by radiation is nil. When this is the case another mechanism comes into play. All over the body surface, in the case of man, there are tiny tubes embedded in the skin, called sweat glands, and these glands secrete a watery secretion that is called sweat. This secretion is poured out all over the body, the surface of the skin becomes wet, and this sweat evaporates into the air, if it is a dry air, in the form of vapour or steam. By this means a considerable amount of heat is lost. In order to change one pint of water at the boiling point into steam as much heat is required as would suffice to heat five pints of water

ice-cold to boiling point. It is obvious, therefore, that sweating forms a very convenient method of getting rid of excess heat in hot weather. Where conditions are unfavourable for evaporation the sweat becomes visible on the skin in drops, and as the heat cannot be lost through evaporation, the only way to keep the temperature down is to keep as quiet as possible. It is owing to this fact that on a wet, muggy, hot day the heat is felt much more than on a hot dry day. We thus see that the body loses its surplus heat chiefly by two methods: (1) by radiation, and (2) by evaporation. Both the skin and the lungs play a part in this heat loss. If the loss by radiation becomes too great in cold weather, a mechanism comes into play which produces more heat. This condition is reached when the body gets into the "shivering" and "teeth-chattering" stage. Shivering is nothing more than an effort on the part of the body to get warm. All these provisions of the body to maintain a constant temperature are presided over by a special temperature-regulating centre that exists in the fore-brain. By means of suitable drugs it is possible to deceive this nerve centre and to persuade it to keep the body at a lower temperature than usual.

In order to guard against excessive loss of heat in cold weather animals are generally provided with a hairy or woolly covering, which acts like a blanket, or in the case of the pig with a thick protective layer of fat under the skin.

The horse is the only farm animal that sweats easily all over the body, that is excepting the legs, which do not sweat. Sweating in the horse takes place first at the bases of the ears, then follow the neck and chest, and finally the hindquarters. It is this easy capacity to sweat that enables the horse to gallop for miles, whereas other farm animals quickly become distressed if moved quickly for any distance. The bullock or cow sweats mainly on the muzzle, and the sheep also sweats very little. In pigs sweating takes place only on the snout.

Practical Deductions.

The following are the practical points that arise from the above remarks:

(1) Clipping or shearing, owing to the blanketing effect of the hair or wool mentioned above, throws a big strain on the heat-regulating apparatus, and should not, therefore, be carried out in wet, cold weather. On the other hand, fat sheep, if left unclipped in hot weather, may die through failure to get rid of the excess heat, as also may pigs over-fatted for show purposes.

(2) In the case of cows the heat produced from the food is sufficient to maintain the body temperature even in cold weather. A cool, airy stable or cowshed is, therefore, preferable to a warm, stuffy one.

(3) In the case of fattening pigs care should always be taken to ensure that the sties are cool and shady in the summer.

How the Animal Utilizes Food.

The living animal resembles to a large extent a steam or petrol engine—it generates power to enable it to function, and provides a surplus which can be utilized for external work. We have discussed in fair detail the nature of the fuel used by the living animal, how this fuel is made available to the animal, and the residues or ash that result from the consumption of the fuel. In animal chemistry, as in the case of an engine, it is necessary to study very closely the kinds of fuel used and its suitability for any particular animal, just as the engineer is obliged to consider the kind of fuel he uses for his engines. This study of foods, or animal fuel, constitutes the major part of the practical education of the farmer, and it is this capacity to utilize the right foods in suitable mixtures for any particular purpose that makes the practical and successful feeder. These practical points will be dealt with in later sections. when describing the feeding-stuffs used in farm practice; at present we are mainly concerned with getting an idea of the purposes for which foods, rightly applied, can be used.

Reverting to our analogy of a petrol engine, this engine is composed of working parts which are constantly being worn away, and which have to be replaced by new parts of a similar material. The working parts of the living animal consist essentially of water, protein and ash, and for repair purposes it consequently becomes necessary to replace these parts by materials of a like nature. This leads to an important fact, i.e. a certain minimum amount of protein is required daily by the animal to repair waste tissue, and without this protein the animal cannot live. In making up a ration for farm animals we must therefore make sure that a certain amount of protein is present.

The petrol engine also has to be supplied with fuel (petrol) in a suitable form. This, when mixed with air, is burnt up and drives the engine. Every motorist is aware that to render the engine efficient and to produce the maximum effect, the exact admixtures of air and petrol must be carefully regulated. Now, the fuel of the animal—which provides the necessary energy to provide work—is derived from the fatty and starchy portions of the food, and in order to make

the most efficient use of the fuel the ratio of the protein to the carbohydrate portion of the food must be carefully regulated. This is the second important fact that we learn, i.e. that each particular animal has a particular ration that is most effective and efficient at any given stage in its career.

Just as the petrol tank contains a reserve supply of petrol for the use of the engine, so the body has a reserve supply of fat that constitutes a reserve supply of food. In starvation the fat reserve is used up first, then follow the tissues of the body, the vital organs of the body, such as the heart and brain being left untouched until the last stages of exhaustion.

Maintenance and Production.

It is also a fact patent to all that a certain amount of fuel—small in the case of the petrol engine—is necessary just to move it, or, to speak technically, to enable it to "tick over." In the case of the living animal a certain amount of food is necessary to enable it just to live and perform its daily vital functions. This is fairly large, and is called its *maintenance requirement*. Only the food supplied in excess of this amount is available for the production of fat, milk, or for the purpose of work. This is an extremely important fact, and cannot be too strongly emphasized. If you halve the amount of food that an animal requires to enable it to produce hard work you do not halve its capacity to work. You may, in fact, do away with its capacity to work altogether, since the half ration provided may be only just sufficient to enable it to live. In making up rations for farm animals it is convenient, therefore, to divide it up into a *maintenance* portion and a *production* portion.

In dealing with a farm animal we have therefore two sets of conditions. In one, the food absorbed is being used to replace waste tissue, to provide energy for work, to provide the requirements of a growing animal, and the hundred and one activities of daily life; in the other, food is being taken in to replace the food used up. We can therefore make a balance-sheet and by balancing the food required against the food used up, estimate and *predict* from the results thus obtained what food an animal will require under any given conditions. Any food supplied in excess of this requirement is wasted, especially protein foods, and the values thus obtained become of real value to the farmer in order to prevent wasteful feeding. Especially is this the case in milk production, and cases are on record where the adoption of a scientific standard has resulted in the saving of many pounds per cow per annum.

Nutritive Value of Food.

Now how can we obtain an idea of the nutritive value of a food? In many feeding experiments carried on both by the educated farmer and the student, two rations are balanced against one another and the differences in increase of live weight of the two sets of animals taken as an indication of the comparative value of the rations fed. Results obtained by this method are only of value when the experimental tests cover a fairly long period and if conducted with a large number of animals. If a bullock is weighed at short intervals of time a variation of weight of 80 lb. may easily be registered. It is owing to these errors, which we call experimental errors, that we find experimenters making statements that, say, 30 lb. of pork may be produced from 56 lb. of food. In an actual experiment 14 lb. of timothy hay was given to a steer which was weighed under experimentally uniform conditions. Its weight on one day was 950 lb., its weight the next day 975 lb. That is, the steer apparently put on 25 lb. of beef for 14 lb. of hay, an obvious absurdity. This first method of experiment is therefore apt to be unreliable, and much caution should be exercised in interpreting the results of experiments obtained by such methods.

The second method available is to feed a set of animals for a given period, carefully analyse the food given and the excreta produced, kill all the animals at the end of the experiment, and analyse the carcases. This method is extremely costly, requires manipulative skill of no mean order, and requires a lot of tedious and patient analytical work. Lawes and Gilbert used this method in their historic investigations, and obtained very valuable results.

A third method, the balance method, is the method usually adopted. In examining a banking account, if we know the cheques drawn during any given month, and the amounts paid in during that month, we can determine how much the account has increased during that period, although we do not know how the account stood at the beginning of the month. In the second method, the slaughter method, we find the amount of the account at the beginning of the month and the amount at the end. The third method, therefore, has its advantages, and is far more easily worked, as will be seen from the example that follows.

Balance of Nutrition in the Animal.

The estimation of the flesh-forming material or protein gained or lost by an animal on a given diet is a comparatively simple affair.

All the nitrogenous materials excreted from the body appear in the urine, the dung and to a smaller extent in the brushings from the coat and skin. In order to obtain the nitrogen balance, as it is called, the nitrogen in the food fed is estimated, and the nitrogen found in the excreta also determined. The difference gives the nitrogen balance, and by multiplying by a suitable factor (six in the case of cattle) the amount of protein put on or lost by the animal during the period of the experiment can be found. The results of an experiment would be tabulated as follows:

ANIMAL—EIGHTEEN-MONTHS-OLD STEER

Daily Nitrogen in Food		·500 lb.
,, ,, ,, Dung		·260 lb.
,, ,, ,, Urine, brushings and skin		·215 lb.
Nitrogen gained	=	·025 lb.
Daily gain of Protein	= 6 × ·025 lb. Protein. = ·15 lb.	

That is, an eighteen-month-old steer, if fed on suitable food, will put on an average of approximately one-sixth of a pound of protein or flesh. From a long series of experiments it has been found that the young animal puts on relatively a large amount of protein, and this decreases as the animal gets older, until, in the case of the mature or adult animal, the body gives off just as much protein as is taken in in the food. The practical lesson to be learned from this is that the young growing animal must be supplied with a diet relatively rich in protein; whereas the adult animal requires a diet relatively poor in protein. Expressing this in another way, we may say that the diet of a young growing animal should contain a nutritive ratio of 1 : 4, and that of an adult animal 1 : 6 to 1 : 10.

Maintenance Requirement in Protein.

By varying the amount of digestible protein given to an animal at different weights it is possible by the method described above to determine for each animal the exact amount of digestible protein required to keep the animal in a state of balance—i.e. in a state where its body is neither gaining nor losing protein. This figure represents the maintenance requirement of the animal, which in the case of a 1,000 lb. bullock is approximately ½ lb. This maintenance figure represents the minimum daily requirement in order that the animal may maintain its normal growth.

Gain or Loss of Fat.

The determination of the gain or loss in fat of the body is not such a simple affair as before, owing to the fact that a considerable amount of the breakdown products appear as carbonic acid gas. In order to determine the fat, the carbon is used as a measure of the fat present, and a carbon balance is drawn up. If such a balance is drawn up and a gain of carbon is shown, the amount of carbon that is derived from or is used by the protein lost or gained by the animal is added or deducted, and the balance is à measure of the amount of fat gained by the animal. An experiment conducted on these lines on a bullock would give a balance-sheet such as follows: Carbon in feeding-stuffs, 106 oz.; carbon in solid and liquid excreta, 60 oz.; carbon in gaseous excreta (lungs and from digestive tract), 44 oz. Therefore the gain of carbon by the body is 2 oz.

In this experiment the animal gained 2½ oz. of protein, which contains approximately 1¼ oz. of carbon. Therefore the gain of carbon represented by fat is ¾ oz. Now, animal fat contains approximately four-fifths of its weight of carbon; ¾ oz. carbon, therefore, represents approximately 1 oz. of fat. Therefore the animal in the above experiment puts on 1 oz. of fat and 2½ oz. of protein. We thus see that it is possible by scientific methods to obtain an accurate idea of what happens to a feeding-stuff when it is fed to an animal.

Determination of Carbon Balance.

It has already been stated above that the determination of the carbon balance is difficult owing to the fact that the gases given off by an animal have to be collected and analysed. To do this, what is called a "Respiration Calorimeter" is used. In practice two types are in use, one an "open circuit" apparatus, and the other a "closed circuit" apparatus. In the latter, a known volume of air passes through a closed chamber in which the animal is placed, and special precautions are taken to keep up a circulation of air and to purify the air coming from the chamber. The same volume of air is used over and over again, the CO_2 and water produced by the animal being removed by suitable absorbents, and the oxygen used up by the animal being replaced by oxygen from an oxygen cylinder. The diagram illustrates the way the apparatus works. (Figure 7.)

In the "open circuit" apparatus a current of air is passed through the apparatus and suitable samples of inlet air and outlet air are analysed from time to time.

The volume of air which passes through the apparatus is also measured, and from these data the scientist calculates the necessary

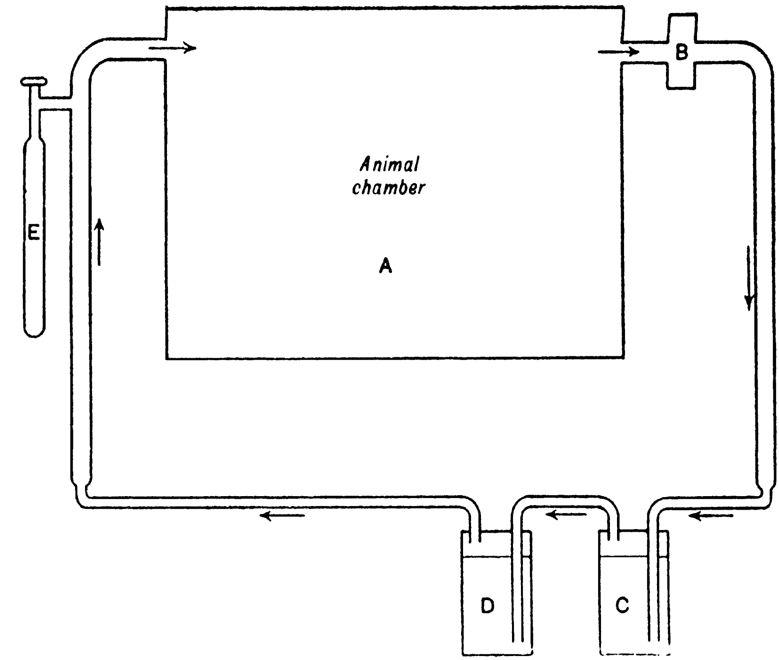


FIG. 7.—"CLOSED CIRCUIT" CALORIMETER

A. Chamber containing animal under experiment. B. Fan to maintain air circulation. C. and D. Purifiers to take up moisture and carbonic acid gas. These can be weighed, and the amount of water and CO_2 produced during the experiment found. E. Oxygen cylinder which supplies oxygen to the purified air.

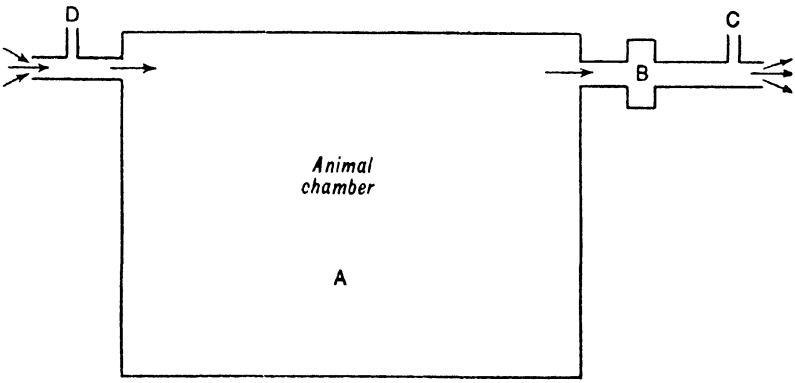


FIG. 8.—"OPEN CIRCUIT" CALORIMETER

A. Animal Chamber. B. Rotary Fan. C. and D. Pipes from which samples of outlet and inlet air respectively are drawn off during the experiment.

figures to give him the carbon balance. Owing to mechanical reasons the open circuit apparatus is in general use. Figure 8 illustrates the principle of the open circuit apparatus.

Energy Balance in the Animal.

It has already been shown that the ultimate fate of the digested nutrients is oxidation in the body—i.e. a burning up. In such a process heat is produced. Similarly when work is performed by an animal heat is produced. If, therefore, we find out how much heat an animal produces under given conditions—i.e. at rest, or when performing work—we can calculate the amount of food it would require to maintain it in good health (1) when at rest, and (2) when performing work, since we can ascertain very readily how much heat a food will give off when burnt in the animal body. This method of attack has been used to a great extent in America, and all our present knowledge on the science of nutrition of farm animals is based on facts derived from the pursuit of the three lines of attack outlined briefly above.

In determining the heat production of an animal under varying conditions, the "open circuit" calorimeter is used, care being taken to insulate the calorimeter so that no heat is lost except in known ways. The apparatus consists of a closed chamber specially adapted to enable the amount of heat given off by an animal to be measured accurately.

Practical Deductions.

From the facts obtained by the above methods we are able to predict with fair accuracy facts like the following: (1) How much food an animal requires to live—i.e. to keep it in the "store" condition; (2) How much food a cow requires to produce a gallon of milk; (3) How much food a cow requires for each gallon of milk above the first gallon; (4) How much food a growing animal requires; (5) How much food an animal requires at work; (6) How much food is required to fatten an animal; (7) How much food a pregnant animal needs; (8) How much food a sheep requires for wool production.

We thus see that research of a purely theoretical nature has given us facts which are of great importance to farmers. The farmer in the past fed his animals by instinct and knowledge of mistakes made, and was governed by rule of thumb methods controlled by experience. To-day the farmer can check the feeding-stuffs he is giving his animals with actual scientific feeding standards and can thus find out whether

he is feeding extravagantly or whether the animals are giving him an adequate return for the foods used.

The Biological value of Feeding-stuffs.

As will be seen later, in working out balanced rations for farm animals we are chiefly concerned with the amounts of digestible protein and digestible energy required by the animal, since these two ingredients can readily be expressed quantitatively in calculating the animal's needs for any given purpose. The extent to which the animal can utilize digestible protein or energy depends, however, on the presence in the ration of certain other factors. These factors are, however, of a qualitative character, in the sense that if they are present in optimal amounts no further addition of them to the diet yields any better result. In formulating diets for any given purpose we therefore need to make sure that we have supplied all the qualitative factors required as well as seeing that the protein and energy are present in the required amounts. In considering the nature of these qualitative factors we are chiefly concerned with (1) the quality of the protein, (2) the nature and amount of the mineral salts present, and (3) the nature and amount of the vitamins present.

The Quality of the Proteins.

In studying the effect of proteins from various sources on the rates of growth of young animals research workers found that whereas good rates of growth could be obtained with relatively small quantities of certain proteins such as lactalbumin from milk, little or no growth could be achieved on the protein of maize called zein, or on the gelatin of bones. Proteins could therefore be roughly classified into two groups, "good" proteins and "bad" proteins. This difference in effect of various proteins naturally stimulated the curiosity of research workers, and after a considerable amount of research work the explanation of this difference between proteins of apparently similar type was found. We have already seen that during digestion proteins are split up into soluble crystalline substances called amino-acids, and the chemist soon discovered that proteins are built up from some or all of twenty or more amino-acids, each of which the chemist has isolated, identified and discovered the exact constitution. It was then discovered that, whereas the animal had the power of manufacturing certain of these amino-acids from others present in the food, there were some of the amino-acids which it could not manufacture or synthesize. These latter, which were

essential for growth, had perforce to be supplied in the diet, and it was then found that the comparative ineffectiveness of such proteins as zein and gelatin was due to the fact that one or more of these amino-acids were absent from the protein molecule. Since these amino-acids were not capable of synthesis by the animal but had to be provided in the diet, they were called essential amino-acids. The amino-acids which are known to be essential are cystine, histidine, lysine and tryptophane. Judged by the relative richness of the various proteins in these essential amino-acids, the general statement can be made that proteins of animal origin with the exception of gelatin are of good biological value, mixed proteins of cereal origin with the exception of germ proteins are of poor value and proteins of legume origin with the exception of soya bean protein and possibly the protein of earthnuts are of moderate biological value. Plimmer and his associates, by comparing the growth increases obtained with equivalent amounts of different proteins, using Light Sussex chicks as experimental animals, obtained the following biological values, taking caseinogen as the standard protein.

Fresh egg white	130·6	Soya beans	55·6
Fresh egg yolk	100·9	Dried egg white	51·2
Caseinogen	100·0	Blood meal	48·0
Fish meal	85·3	Split peas	45·0
Dried egg yolk	80·5	Bean meal	36·3
Meat meal (fat free)	74·1	Alfalfa or Lucerne	25·6
Wheat germ	68·0	Grass	22·0
Meat meal	62·8	Lentils	19·0
Dried yeast	62·0		

This table illustrates the general superiority of animal proteins over plant proteins, and also illustrates the adverse effect on the quality of a protein that may be brought about by desiccation (e.g. egg white).

The distribution of some of the essential amino-acids in the mixed protein of feeding-stuffs will be noted from the table which follows; the figures representing the relative amounts of amino-acids present in 100 parts of the feeding-stuff.

These figures are instructive in the sense that we note that the good proteins are rich in essential amino-acids, and they further emphasize the fact that, whereas proteins from a single food source may possess poor biological value, proteins derived from several food sources are almost certain to be of good biological value, particularly if we include proteins of animal origin. The practical lesson to be drawn from this is that, in formulating diets, we should

always include protein of animal origin, or failing that, we should make the diet a varied one.

Feeding-stuffs	Arginine	Histidine	Lysine	Cystine
Alfalfa or Lucerne	·580	·329	·537	·197
Barley	·403	·174	·156	·137
Beans	1·135	·621	1·579	·351
Sugar-beet pulp, (dried) ..	·028	·020	·021	·043
Blood meal	5·025	2·583	7·456	2·940
Clover hay	·459	·402	·297	·163
Cotton-seed meal, (dec.) ..	3·906	1·782	1·474	·548
Dec. earthnut cake	3·680	2·557	1·740	·643
Linseed cake	1·823	·812	·849	·377
Maize	·428	·280	·182	·146
Flaked maize	·403	·137	·177	·197
Meat meal	6·262	1·465	5·293	1·388
Dried skim milk	1·457	1·232	2·282	·917
Oats	·595	·354	·245	·129
Peas	1·212	·435	1·318	·480
Soya-bean meal	3·481	1·476	2·303	·883
Wheat	·443	·111	·229	·206
Wheat bran	·831	·402	·552	·334

Mineral Substances.

The living cell depends for its very existence on the presence of certain mineral salts in the cell fluids and protoplasm; the absence of an essential mineral constituent or an excess of acidity or alkalinity leads ultimately to death. Thus the efficient functioning of the muscles of the body depends upon the presence in the fluids bathing the muscle of certain salts of potassium, calcium, sodium and magnesium in well defined concentrations. Both manganese and magnesium have also been shown to be essential for the normal growth of animals, and minute traces of copper have been proved essential for the adequate utilization of iron by the body. Similarly, calcium has been found to play an essential rôle in the clotting of milk and blood, and both calcium and phosphorus are necessary for bone formation. Without the red colouring matter of the blood (hæmoglobin) the blood is unable to absorb the oxygen so necessary for the functioning of all life processes, and since iron forms an essential part of hæmoglobin, it is hardly necessary to emphasize the primary importance of iron as a mineral constituent of the food supply. Inadequate mineral intake, in fact, is often primarily responsible for cessation of growth, or onset of cramp, softening of the bones and development of rickets, anæmia, depraved appetite, the production of thin-shelled eggs and reduction of milk yield. The importance of an adequate mineral intake in the food consequently needs no emphasis. From the nutritional point of view we are chiefly con-

cerned with the nature of the minerals supplied in the food and the extent to which the minerals present in the food need to be supplemented by mineral mixtures.

In the case of the suckling animal, milk forms the sole source of food. If we compare the time taken by various animals to double their birth weights with the amounts of protein and mineral constituents present in 100 parts of the milk, we should be able to trace any relationship that may exist between protein and ash content and growth rate. It is a remarkable fact that the longer the time taken to double the birth rate, the less the percentage of protein and ash present. Thus, placing the following animals in order of decreasing times required to double their birth weights, we find that the protein percentage in the milk and the ash percentage in the milk shows a progressive increase, in exactly the same order, i.e. man, steer, goat, sheep, pig, dog, rabbit. The value of milk in animal nutrition not only, therefore, depends upon the protein and energy supplied by it, but also to a considerable extent on the fact that the essential minerals are supplied in the nature and amounts required by the growing animal, and in a form capable of easy assimilation. It is, however, necessary to realize that milk is actually deficient in one essential mineral ingredient, namely iron. The reason for this is that the liver of the newly-born mammal contains normally sufficient iron to supply its requirements during the suckling period; under certain conditions, however, this iron reserve may be inadequate. In fact, it has been established that conditions of anæmia often arise in sucking pigs reared under hygienic conditions which preclude their access to earth or soil, and that these conditions may be prevented by allowing such pigs access to barley water containing a small proportion of a suitable iron tonic.

In considering the mineral needs of the growing animal, and particularly the necessity of supplying mineral supplements, the question resolves itself into ascertaining the nature and amount of mineral substances stored in the body and the ability of the normal food to supply these requirements. By taking the fowl as an example, we can obtain a fairly clear picture of what is happening during growth. At the age of 1 week, the ash in the fat-free dry matter of the body is approximately 11%; it then rises rapidly in the next five or six weeks to a level of approximately 17% but after that period it remains approximately steady, though slightly increasing until it reaches a level of approximately 18% as maturity approaches. It is important to remember, however, that the bird is steadily growing all the time, and if we consider the actual

amounts of ash deposited in the body, we find that there is a relatively low rate of deposition up to 7 weeks and a rapid rate of deposition from 7 weeks up to the 24th to 26th week of age, after which period the deposition rate slows down. The interpretation of the above facts are as follows: In the very young animals the skeleton consists largely of cartilage, and in the early stages of growth deposition of bone salts is actively taking place. This results in the rapid increase of percentage of ash noted above, but since the animal is still small, the actual amounts of ash deposited are small. After this initial calcification process, growth becomes very rapid, both the bones and the muscles and soft parts of the body taking part until the stage is reached where the animal is fully grown. It is on account of this parallel development of bone and muscle that we find that the ash percentage of the fat-free dry matter of the carcase remains steady, although at the same time the amounts of ash stored are considerable. The practical consequences of these facts are that special attention needs to be paid to the nature of the mineral constituents in the early stages of an animal's growth, since any mineral deficiencies in the diet will make themselves evident; but that special attention needs to be paid to the amounts of mineral constituents in the later stages of growth.

PERCENTAGE ASH IN FRESH MEAT AND BONE

Age	Cockerels		Pullets	
	Meat	Bone	Meat	Bone
8 weeks	1·14	8·78	1·28	9·08
12 weeks	1·12	9·60	1·04	9·92
16 weeks	1·04	10·00	1·07	10·62

If we consider the percentage of ash present in the soft tissues of the body with that present in the bone, as growth proceeds, we note that whereas the ash of the meat remains approximately constant, that in the bone gradually increases. If, moreover, we ascertain the respective amounts of ash in the carcase of an adult fowl, it will be found that approximately 80% of the ash of the body is in the bones.

By analysing the ash yielded by the soft tissues and that yielded by the bones, we obtain some further interesting facts. We note, for instance, that the majority of the calcium of the body is stored in the bones, as is a large proportion of the phosphorus and magnesium. The sulphur, potassium, sodium, chlorine and iron are, on the other hand, chiefly present in the soft tissues.

MINERAL INGREDIENTS, IN GRAMS, IN A MATURE COCKEREL

	Flesh and Offal	Bones
Ash	17·640	68·740
Total phosphorus	2·848	11·600
Phosphorus in ash	2·178	11·520
Total sulphur	3·733	0·922
Sulphur in ash	0·173	0·205
Calcium	0·430	25·68
Magnesium	0·478	0·807
Potassium	4·778	0·787
Sodium	1·443	0·713
Chlorine	2·283	0·817
Iron	0·131	0·030

If we now consider the composition of plant ash, we shall find that, as a general rule, plants and plant products are deficient in chlorine, sodium and calcium, but contain considerable amounts of potassium, phosphorus and magnesium. On the other hand, foods of animal origin, such as milk, fish meal, meat meal, etc. are richly supplied with all the mineral ingredients present in the animal body. Moreover, although plants and plant products are reasonably rich in phosphorus, this phosphorus is often present in a non-assimilable form. Consequently, animals fed on plants and plant products are likely to find their diet deficient in sodium, calcium, chlorine and phosphorus. It is consequently not surprising to find that the mineral supplements given to farm stock consist of sodium chloride (common salt), some form of calcium carbonate, and calcium phosphate.

In addition to the minerals already mentioned, there is present in the thyroid gland of the animal iodine in a combined form. Iodine is consequently an essential mineral, and complete absence of this mineral from a diet leads to thyroid disease, with consequent disturbance of the body's functions. For this reason, small quantities of potassium iodide are often included in mineral feeding mixtures, particularly in those areas of the world including this country, in which it is known that the soil and water supplies contain no iodine.

Apart from the specific effects of mineral ingredients with which we have already dealt, there is another aspect that needs consideration. According to the nature and amounts of mineral ingredients present, a feeding stuff is either acid-forming or alkali-forming, potassium, sodium, calcium, magnesium and organic acids giving rise to alkaline conditions in the body, sulphur, phosphorus and inorganic acids giving rise to acid conditions. An ideal food mixture should be such that its effect on the body is either neutral or slightly

alkali forming. Foods which are moderately to medium alkali-forming are meadow hay, grass, root crops, silage, milk, and milk by-products, linseed, soya and earthnut cakes; leguminous crops and molasses being strongly alkali-forming; whereas cereal grains, wheat offals, peas, beans, meat meal, fish meal and cotton-seed meal are acid-forming. It is at once apparent, from consideration of these facts, why it is that chalk is so essential an addition to the normal diet of the pig and the fowl, since the foods used are all of an acid-forming character.

Vitamins.

Until the beginning of the twentieth century, if a food contained protein, fat, carbohydrates and minerals, together with a certain amount of woody fibre to act as roughage it was considered to be a complete food. This belief was due to the fact that a varied diet consisting of natural foods containing these substances had proved adequate, and when the chemist analysed a food, the percentages of moisture, protein, ash, fat, carbohydrates and woody fibre added up to approximately 100%. Although the disease, known as beri-beri, made its appearance in the rice-eating districts of the East when milling machinery was introduced from the West, and scurvy was known to occur among sailors fed on salt meat and biscuit, the realization that these diseases were due to food deficiencies and not to pathological organisms was slow of recognition by scientists and dietary specialists. Lunin, as early as 1881, had come to the conclusion that foods such as milk contain, besides the principal ingredients, small quantities of unknown substances essential to life, and Eijkman in 1897 had satisfied himself that the disease beri-beri was due to the continued consumption of polished rice. Moreover, in the eighteenth century the value of lime juice as a preventive of scurvy was recognized in the British Navy. The significance of these facts in their relation to diet was not, however, properly appreciated until scientists began to turn their attention to problems involving the use of artificial or synthetic food mixtures for animal feeding. It was then found impossible to keep animals alive on such diets unless they were given a small proportion daily of a natural food such as milk. With this realization, that certain substances, minute in amount and whose identity was unknown to science, were essential for the maintenance of life and the efficient utilization of the main ingredients of the food, a new door to the hidden mysteries of science was opened, with the result that at the present day we can utilize

the knowledge thus gained to maintain animals in perfect health under almost any condition of environment. These substances, which though present in minute amounts in feeding-stuffs, nevertheless played an essential rôle in the maintenance of life, were called by Funk vitamines in allusion to the fact that they were essential to life and were assumed to be chemically of the nature of amines. Later, when it was realized that this conception of their chemical nature was incorrect, at Drummond's suggestion the final e was dropped, so now we refer to them as "vitamins."

Since these substances are so essential in human and animal dietaries a short account of their nature, occurrence and symptoms of their deficiency or absence from a diet may not be out of place. It is, however, important to realize that these food factors are qualitative in character and that the reaction of different species of animals to their absence is variable. Thus man and the guinea pig react severely to the absence of the anti-scorbutic vitamin, fowls and ruminants, on the other hand are unaffected. Also, a food rich in a particular vitamin will produce spectacular results if added to a diet deficient in this vitamin, but may give little or no result if the diet already contains adequate amounts of this vitamin.

VITAMIN A.

This substance is essential to life and growth, and to the maintenance of healthy, normal epithelial and glandular tissues. The breakdown of the epithelial tissues that occurs in its absence from a diet renders an animal more liable to surface infection of harmful bacteria and consequently disease. On this account, it is often referred to as an anti-infective vitamin. It is largely derived from a lipochrome pigment called carotene which is converted into vitamin A by the liver cells of the animal. It is also relatively heat stable, but is easily destroyed by exposure to the air.

Occurrence. Vitamin A or its precursor, occurs in green foods, carrots, animal fats, most fish oils, maize, palm oil, wheat bran, wheat-germ oil, wheat, barley, leguminous seeds, milk and milk by-products. Cereal grains, apart from those already mentioned, contain little or no vitamin A, and plant fats and oils are also deficient in this vitamin.

Symptoms of deficiency. The symptoms of deficiency are cessation of growth followed by development of sore and inflamed eyes, infections of the throat and respiratory passages, and in man, night blindness. In the fowl, the kidneys are also affected. Finally, emaciation and death results.

VITAMIN B COMPLEX.

Recent research has shown that vitamin B, instead of consisting of a single factor, is in reality a complex containing several vitamins. Vitamins B_3 and B_5 are growth factors for pigeons, and vitamin B_4 a growth factor for rats. In the United States, vitamin B_1 is called vitamin F and vitamin B_2 is called vitamin G.

Vitamin B_1 (anti-neuritic).

Absence of this vitamin from a diet leads to the disease known as beri-beri in man. In animals its absence leads to the development of paralysis, loss of appetite and cessation of growth and eventual death. This vitamin is readily destroyed by moist heat and in the presence of alkalis, but withstands dry heat. This vitamin has now been identified and synthesized, and is known as thiamin.

Occurrence. This vitamin is widely distributed in naturally occurring feeding-stuffs, particularly green foods, root crops, cereal grains and their by-products, liver and yeast. Milk contains very little.

Vitamin B_2 complex.

On a ration devoid of this substance, growth is retarded and chicks will develop pellagra at 3 weeks of age. This disease exhibits itself in chicks as retarded feathering, development of crusty scabs at the corners of the mouth, and lesions may also be found in the gizzard and duodenum. There is evidence that this vitamin is not a single substance, and at the present moment is subdivided into three separate components, i.e. lactoflavin or riboflavin, nicotinic acid, and vitamin B_6. Lactoflavin is growth promoting. Nicotinic acid prevents pellagra in man, and "black tongue" in dogs, and vitamin B_6 prevents pellagra in rats. The components of vitamin B_2 are more heat resistant than B_1.

Occurrence. Vitamin B_2 is present in cereal grains, particularly the bran and the germ, green foods, meat, particularly liver and milk and its by-products, particularly whey and whey powder. Liver and yeast are both rich sources of this vitamin.

With regard to vitamin B_3 and B_4 our present knowledge is scanty. Vitamin B_3 is considered essential for the pigeon, and absence of vitamin B_4 from the diet is characterized in the chick by subnormal growth, lack of nervous co-ordination and paralysis of the leg muscles. The nervous tissue of the brain appears to be affected. Vitamin B_4 is present in liver and certain green plants such as blue grass.

Vitamin C (anti-scorbutic).

This vitamin has been proved to be a substance called ascorbic acid. It is found in considerable amounts in fresh fruits and vegetables, and to a lesser extent in fresh meats and milk. This substance is destroyed by heat, consequently dried foods contain little or none. Although absent in cereal grains, it is formed during germination and is a common constituent of sprouted seeds. Its absence from a diet gives rise to scurvy.

VITAMIN D (*anti-rachitic*).

This vitamin plays an important part in calcium and phosphorus metabolism, and its absence from a diet causes rickets in animals kept in certain environments. Several forms of vitamin D are known, among which vitamin D_2 (calciferol) and vitamin D_3 are important. Vitamin D_2 prevents "rickets" in man and the rat, and is derived from ergosterol. It is not very effective in preventing rickets in chicks. Vitamin D_3, present in fish oils, is derived from "dehydrocholesterol" and is very efficacious in preventing "rickets" in chicks. The potency of this compound may be realized by the fact that 1 gramme of vitamin D_3 would suffice to protect 100,000 chicks from day-old up to the age of 8 weeks. This vitamin is more stable to heat and oxidation than vitamin A and meals containing vitamin D in the form of cod-liver oil have been proved to retain their vitamin D potency unimpaired for periods up to at least six months.

Deficiency Symptoms. Animals deprived of vitamin D cannot utilize the calcium and phosphorus of their diets for bone formation; consequently in the young animal develops the condition known as "rickets." This disease is characterized by bowing of the leg bones, swelling of the joints and in severe cases beading of the ribs and in the case of chicks, deformity of the breast-bone. In the case of adult animals, softening of the bones results, and in the case of laying fowls decrease in egg production with the laying of thin-shelled eggs occurs, often accompanied by paralysis.

Occurrence. Vitamin D occurs in animal fats, milk, liver and in certain fish liver oils, particularly cod-liver oil. The vitamins in the cod liver are originally derived from the minute green plants of the sea called phytoplankton, which form the food of minute crustacea. These in turn are eaten by small fish such as squid and caplin, which in turn form the food of the cod. The phytoplankton can only survive in the presence of light. It is therefore an interesting fact to note that animals in the presence of sunlight are able to dispense with the need

for vitamin D in their diets. It has been shown that this is due to the fact that certain sterol compounds present in the animal's body are converted into vitamin D by the action of sunlight or ultraviolet light. This fact is of considerable practical importance, because it teaches us that only when animals are kept under conditions which preclude them from access to the sun's rays do we need to consider the vitamin D content of their diets.

VITAMIN E (*anti-sterility vitamin*).

This vitamin, the absence of which in a diet leads to sterility, is found in green leaves and the germ of cereals. It is heat resistant and resists attack by acids and alkalis. Sterility due to this cause is not therefore likely to arise, since their natural foods contain adequate amounts of this vitamin. Nevertheless, the practice of giving wheat germ oil to breeding animals, particularly race-horses, is increasing. This vitamin has now been isolated, and is called α-tocopherol.

Vitamin K (*anti-hæmorrhagic vitamin*).

This vitamin is heat resistant and fat soluble, and is present in pig's liver, hempseed, and certain vegetables such as kale and tomatoes, and to a lesser extent in cereal grains. Its absence from a diet causes weakness of the walls of the blood capillaries, and a delayed clotting time in the blood. Consequently, animals suffering from deficiency of this vitamin tend to bruise easily when handled, and bleeding easily occurs. In chickens the disease is characterized by the occurrence of extensive hæmorrhages in the breast, legs and wings, also within the muscles and lining membrane of the gizzard.

We thus see that it is essential, in constructing a diet, to ensure that all the necessary vitamins are present, since their absence may lead to disastrous consequences. We also note that the need for vitamins varies with the class of stock we are dealing with, and particularly with the conditions under which they are kept. Finally, we note that if the animals are kept under natural conditions where they can obtain abundant exercise and sunshine, and where their diets are varied and consist of naturally occurring feeding-stuffs, the need for considering their vitamin requirements largely disappears. It is only when we try to keep animals under unnatural conditions and feed them on prepared foods from restricted sources that we need to exercise care to see that they are supplied with an adequate vitamin intake.

CHAPTER IV

FEEDING STANDARDS

Historical.

THE idea of expressing the nutritive requirements of livestock in terms of feeding standards has undergone slow but steady evolution with the progress of our knowledge in the chemistry of foods and the physiology of digestion. As early as 1809 Thaer set out to establish a table of equivalents in which the different feeding-stuffs in common use for farm livestock could be equated on a common basis, and with the help of his chemical colleague, Professor Einhof, a table of equivalents was established, using hay as a standard of comparison. These "hay equivalents" were obtained by comparing the amount of the feeding-stuff that was rendered soluble by treatment with warm water, dilute acid and dilute alkali, with the amount rendered soluble by equivalent treatment of a similar sample of average hay. By this method of estimation, each of the feeding-stuffs was given a number which represented the number of pounds of the feeding-stuff in question that contained the same amount of soluble nutrients as 100 lb. of meadow hay. By expressing the food requirements of an animal in terms of hay, it thus became possible to substitute any of the other feeding-stuffs in equivalent proportion and so to build up rations for any given purpose from the feeding-stuffs available on the farm. This system, defective though it was, proved of such value that its use quickly spread through Central Europe. In 1836, the work of Magendie, Macaire and Marcet on the part played by nitrogenous substances in the nutrition of animals so impressed Boussingault that he published a table of "hay equivalents" based on the nitrogen content of the feeding-stuffs. Meanwhile considerable advances were being made in our knowledge of the chemical composition of feeding-stuffs and the nature of the chemical composition of the animal body. Liebig, in 1842, recognized the presence in foods of a nitrogenous group of substances of food value such as albumin, flesh and blood, and a non-nitrogenous group such as fat, starch, gum, sugar, pectins, etc. Lawes and

Gilbert, at Rothamsted, had shown to what extent these two groups of substances were present in the bodies of farm animals at different stages of growth and fatness, and Claude Bernard had demonstrated the important part played by non-nitrogenous substances in animal physiology. Henneberg and Stohmann, armed with this newer knowledge, by a carefully designed series of feeding experiments with sheep and oxen, had little difficulty in clearly proving that the Thaer's hay equivalent system was unsound. Emil von Wolff, Director of the Royal Agricultural College of Hohenheim, had already realized the unsoundness of the Thaer system and had attempted to modernize it by taking into account the woody fibre and nitrogenous substances of the feeding-stuff as well as the soluble substances given by Thaer, but the publication of Henneberg's researches caused him to abandon the task. In 1859 Grouven published feeding standards based on the total quantities of protein, fat, and carbohydrates as measured by chemical analysis.

The Digestible Nutrient System.

In 1874 Emil von Wolff made a considerable advance by expressing in terms of *digestible* protein, carbohydrates and fat the nutritive requirements of the dairy cow. This feeding standard was based on a careful survey of all the existing dairy-cow feeding trial data, but the idea of distinguishing between the maintenance portion of a ration which served to maintain the body weight of the animal and to enable it to carry out its vital functions, and the production portion which enabled the animal to produce live-weight increase or milk or to perform useful work, was not then recognized. The distinction between the maintenance portion of a ration and the production portion of a ration we owe to Professor Julius Kühn, who in 1887 in his book on feeding, *Die zweckmässigste Ernährung des Rindviehs*, not only stressed the need for distinguishing between the maintenance and production portions of a ration, but also stressed the importance of taking into account the total dry matter of the ration and also distinguishing between the digestible albuminoids and amide compounds in estimating the protein requirements. In 1897 Dr. C. Lehmann published a modified Wolff-Lehmann feeding standard in which he embodied Kühn's findings, and this modified system found general adoption wherever systems of rationing were practised. The next step, so far as the rationing of dairy cows was concerned, took place in 1903, when Haecker published a digestible nutrient standard in which he made allowances for milks of different quality, particu-

larly with regard to their fat content. This standard, with subsequent modifications by Savage and Morrison has since been generally used by dairy farmers in the United States of America.

The Starch Equivalent System.

By means of digestibility determinations with horses, cattle, sheep and swine, a table of digestible nutrients of the commoner feeding-stuffs had been constructed chiefly by German workers, among whom we may mention E. von Wolff, Heiden, Winke, Henneberg and Stohmann, and by means of carefully controlled feeding trials, feeding standards were established, utilizing these digestible nutrients as a basis. Meanwhile the work of Voit and Pettenkofer, Rubner, Zuntz, Meissl and others had established the value of energy balance studies as a method of investigating the nutritive values of feeding-stuffs. In Germany, Gustav Kühn, at Mockern, initiated a series of experiments using the respiration calorimeter as an instrument of precision, and these experiments were brought to a brilliant conclusion by O. Kellner, who succeeded Kühn in 1893. These energy balance studies clearly showed that the digestible nutrients of a feeding-stuff did not accurately represent its true nutritive value.

Using mature oxen, Kellner determined the relative rates of conversion of food fat, protein and carbohydrate to fat in the animal body. The method of attack was to place the oxen on a maintenance ration, and to study the energy gains resulting from the addition of predetermined amounts of starch, straw pulp, wheat gluten and oil to this basal diet. From these studies Kellner established the following facts:

Digestible Nutrient (1 kilogram).	Energy Stored (kilocalories).	Equivalent to grams Body Fat.
Protein	2,233	235
Starch and crude fibre	2,356	248
Cane sugar	1,786	188
Fat	4,503–5,681	474–598

Kellner, realizing that the fat-producing power varied from individual to individual and even in the same individual according to its stage of fatness and its pre-experimental nutritional history, decided, in drawing up a feeding standard, not to give the absolute amounts of energy that a feeding-stuff would yield, but to express this value in a comparative form, using starch as a basis. It is important to realize this fact, since a lot of the trouble that research

workers have met with subsequently has been due to the attempt to express the production values of feeding-stuffs in absolute form. Thus, the net energy conception of Armsby in the United States has recently been abandoned in favour of expressing the requirements of animals in terms of digestible nutrients.

Taking starch as the unit, and assuming that it is 100% digestible, 1 kg. starch has a production value of 248 grams of body fat. The starch equivalents of digestible pure nutrients then work out as follows:

1 part digestible protein	=	0·95 parts starch equivalent.
1 part digestible fat—		
(in coarse fodders, chaff, roots and their by-products)	=	1·91 " " "
(in grains and by-products)	=	2·12 " " "
(in oil seeds and cakes and products of animal origin)	=	2·41 " " "
1 part digestible N-free extract and woody fibre	=	1·0 " " "

Applying these factors to the digestible nutrients of cotton-seed meal, linseed cake meal, palm kernel cake meal and earthnut meal, Kellner found that the theoretical body fat production agreed very well with that actually obtained by experiment. The actual results were:

Per 100 grams Feeding-Stuff (Dry Matter).	Body Fat (Calculated) in Kilocalories.	Body Fat (Actual) in Kilocalories.
Cotton-seed meal	191·4	186·9
Linseed cake meal	186·8	182·8
Palm-kernel cake meal	170·5	173·9
Earthnut meal	179·5	179·8

On the other hand, when he carried out similar tests with coarse fodders he found considerable divergence between the theoretical and actual values. The actual values were:

Per 100 grams Feeding-stuff (Dry Matter).	Body Fat (Calculated) in Kilocalories.	Body Fat (Actual) in Kilocalories.
Wheat straw	98·9	20·1
Oat straw	103·6	62·8
Barley straw	111·1	74·7
Meadow hay	122·8	77·1
Clover hay	118·3	81·1

This discrepancy between the actual and the theoretical values he associated with the fibre content of the coarse fodders, owing to the energy expended by the animal in reducing the fodder to a form suitable for digestion. He actually found that, whereas if the fodder was fed in the natural state the deficit amounted to 1·36 kilocalories for every gram of crude fibre, this deficit was reduced to 0·70 kilocalories per gram of crude fibre in the case of wheat chaff, or if the fodder were reduced to the size of wheat chaff by mechanical means.

In order to reconcile theory with practice, Kellner assigned to each concentrated feeding-stuff a "value number" The starch equivalents as ascertained from the digestible nutrients multiplied by the value number and divided by 100 gave the true starch equivalent of the feeding-stuff. In the case of the fodders a different procedure was adopted, a variable deduction from the starch equivalent being made according to the crude fibre present.

In English feeding standards the Kellner starch equivalent system is adopted and the tables given in the Appendix have been calculated on the basis given below.

Name of Fodder.	Deduction for every per cent of Crude Fibre.
Hay and straw chaff	0·29
Long hay or straw	0·58
Green fodders:	
Containing 4% and less crude fibre ..	0·29
,, 5% ,, ,, ,, ,, ..	0·31
,, 6% ,, ,, ,, ,, ..	0·34
,, 7% ,, ,, ,, ,, ..	0·36
,, 8% ,, ,, ,, ,, ..	0·38
,, 9% ,, ,, ,, ,, ..	0·40
,, 10% ,, ,, ,, ,, ..	0·43
,, 11% ,, ,, ,, ,, ..	0·45
,, 12% ,, ,, ,, ,, ..	0·48
,, 13% ,, ,, ,, ,, ..	0·50
,, 14% ,, ,, ,, ,, ..	0·53
,, 15% ,, ,, ,, ,, ..	0·55
,, 16% or more crude fibre ..	0·58

Examples:

Linseed cake. Value number, 97.

23·9% digestible protein	× 0·95	= 22·7%	starch equivalent.		
8·7% ,, fat	× 2·41	= 21·0%	,,	,,	
28·5% ,, carbohydrates	× 1·0	= 28·5%	,,	,,	
4·5% ,, fibre	× 1·0	= 4·5%	,,	,,	
	Total	= 76·7%	,,	,,	
	76·7 × 97%	= 74·4%	,,	,,	

Crimson clover. Crude fibre content 6·2%.

1.5%	digestible protein	× 0·95	=	1·4%	starch equivalent.
0·5%	" fat	× 1·91	=	0·9%	" "
8·8%	" carbohydrates and fibre	× 1·0	=	8·8%	" "
		Total	=	11·1%	" "
		Deduct 6·2 × 0·34%	=	2·1%	" "
		Starch equivalent	=	9·0%	

Meadow hay. Crude fibre content, 26·3%.

3·8%	digestible protein	× 0·95	=	3·6%	starch equivalent.
1·0%	" fat	× 1·91	=	1·91%	" "
40·7%	" carbohydrates and fibre	× 1·0	=	40·7%	" "
		Total	=	46·2%	" "
		Deduct 26·3 × 0·58%	=	15·2%	" "
		Starch equivalent	=	31·0%	

Meadow hay chaff. Crude fibre content, 26·3%.

Starch equivalent from digestible nutrients, as above		=	46·2%
	Deduct 26·3 × 0·29%	=	7·6%
	Starch equivalent	=	38·6%

The Scandinavian Food Unit System.

The development of feeding standards for fattening cattle, cows, horses, sheep and pigs in the Scandinavian countries followed purely practical methods of experimentation. The method consists of ascertaining the comparative values of various types of food for milk production, growth, work production, fattening, etc., by means of "group feeding" experiments or "period" experiments. In the group-feeding experiment, groups of animals are selected as near alike as possible so far as age, weight, and productive capacity are concerned, and all groups are placed on a standard diet for a preliminary period to ensure that they react similarly to the same conditions of feeding. Having ensured by this method that the groups are uniform, the experiment proper is carried out, a basal ration being given and a known quantity of the foods under test added, each group receiving a different food. Thus in an experiment with dairy cows, three groups of cows, six cows in each group, were fed during the pre-experimental period of three weeks with a basal ration supplemented with 2 kg. per head per day of sunflower cake. During the experimental period proper of four weeks, Group 1 received the basal ration plus 2 kg. sunflower cake, Group 2 the

basal ration plus 2 kg. soya meal, and Group 3 the basal ration plus 2 kg. soya cake. A post-experimental period of two weeks then followed in which all groups received the basal ration plus 2 kg. of sunflower cake. The data obtained were as follows:

	Milk Produced per Head per Day (kg.).			Milk Production compared with Control.
	Pre-experimental Period.	Experimental Period.	Difference.	
Group 1 2 kg. sunflower cake	14·45	14·02	—0·43	0·00
Group 2 2 kg. soya meal ..	14·43	14·66	+0·23	+0·66
Group 3 2 kg. soya cake ..	14·44	14·70	+0·26	+0·69

On the basis that one food unit produces 3 kg. of average milk and that 0·91 kg. sunflower cake equals one food unit, 0·66 kg. milk equals 0·20 kg. sunflower cake and 0·69 kg. milk equals 0·21 kg. sunflower cake. Consequently 2 kg. soya meal are equivalent to 2·20 kg. sunflower cake, and 2 kg. soya cake are equivalent to 2·21 kg. sunflower cake. In the period group method of experimentation one group only of cows is used, and the experiment is divided into three periods. In the first and last periods the control ration is used, in the second period the food under test is added. The results in the second period are then compared with the average results of periods one and two.

Instead of using starch as a unit, the Scandinavian system uses 1 kg. of barley as a "food unit." This system has the merit of comparing the values of foods on the basis of actual results when applied in practice, consequently any specific value that the food may possess in addition to its protein and energy values receives proper recognition. It is an extremely valuable method of expressing food values under agricultural conditions in which all farmers farm on the same rotations and consequently use the same mixtures of feeding-stuffs, but it is not applicable to those countries in which the types of farming are diversified and the classes of feeding-stuffs available show great variation from district to district. It is chiefly on this account that the system has not been adopted in England and the United States.

Armsby's Net Energy System.

In the United States, Armsby developed a feeding standard by experimental methods similar to Kellner, but expressed the food values not in terms of starch, but in terms of energy, using the "therm" (1 therm = 1,000 kilocalories, or 1,000,000 small calories) as a unit. In Armsby's system, the metabolizable energy of a food is the gross energy of the food as measured in a bomb calorimeter less the energy of the excreta. (Food energy minus energy of dung, urine, and gaseous excreta, such as methane).

When a food is utilized for the purposes of production a portion of this metabolizable energy appears as heat. This portion is called the "increment of heat production," and the net energy of the food consists of the metabolizable energy of the food less the energy of the increment of heat production. Armsby's net energy conception assumed that the energy of the increment of heat production could under no circumstance be utilized by the animal, an assumption not above criticism, in view of the fact that, for maintenance purposes, a certain proportion of the energy of a food is utilized for the maintenance of the body temperature. It is therefore conceivable that the utilization of food energy for maintenance is more efficient than for fat production, and it is interesting to note that the results of work planned by Armsby before his death have proved this to be the case. The work of Forbes and his associates at the Pennsylvania Institute of Animal Nutrition has shown that the efficiency of utilization of a feeding-stuff for maintenance differs from that for body increase, and that this in turn differs from that for milk production. Consequently, Forbes and Kriss have abandoned the net energy system for the expression of feeding standards and have replaced it by one in which the requirements are expressed in terms of metabolizable energy and total digestible nutrients.

English Feeding Standards.

As already explained, the energy available in a feeding-stuff for maintenance or production is expressed in English feeding standards as "starch equivalent."

In constructing a ration for any particular purpose, we differentiate between that portion of it required for maintenance of the body weight and vital functions (the *Maintenance Ration*) and that portion available for production (the *Production Ration*). These two rations are expressed in terms of digestible protein and starch equivalent.

In expressing the digestible protein, it is sometimes customary to express it in terms of digestible crude protein (digestible nitrogen $\times 6{\cdot}25$), or in terms of digestible pure protein. The digestible crude protein is made up partly of pure protein and partly of non-protein nitrogenous substances such as amides, etc. There is evidence that such non-protein nitrogenous substances have a nutritive value, particularly in the case of ruminants, approximating half that of pure protein. Consequently the protein requirement is sometimes expressed in terms of *protein equivalent*, the protein equivalent being half the sum of the digestible crude protein and the digestible pure protein. In addition to the protein and starch equivalent, it is necessary to take into account the fact that the consumption of food by an animal is limited by its digestive capacity, consequently in addition to the protein and starch equivalent figures a measure of its daily food capacity is given in terms of dry matter.

In addition to these factors, it is essential to take into account such things as the quality of protein, the mineral content and the vitamin content. All these factors are included by careful consideration of the foods used in making up a ration, and are not usually capable of quantitative expression. Consequently, a feeding standard normally gives only the protein requirement, the starch equivalent, and the daily dry matter, but it is essential to realize that these other factors have to be provided for, and it is partly on this account that it is not possible always to build up a satisfactory ration by consideration only of the data given in a feeding standard.

Instead of giving a standard in terms of digestible protein and starch equivalent, it is sometimes more convenient, particularly when the foods used have similar energy values, to express the standard in terms of meal or dry matter only. In such a case, the balance between the protein requirement and the energy requirement is maintained by stating the *nutritive ratio* of the ration. The nutritive ratio expresses the ratio between the digestible nutrients of the non-protein portion of the food and the digestible crude protein. It is calculated by adding together the percentages of digestible carbohydrates, including digestible crude fibre to the percentage of digestible fat multiplied by 2·3, and dividing the figure so obtained by the percentage of digestible crude protein.

Feeding Standards for Dairy Cows.

The generally accepted standards for the feeding of daily cows are:

For maintenance:

6 lb. starch equivalent including 0·6 lb. protein equivalent per 1,000 lb. live weight daily.

For the production of a gallon of milk:

Fat Content %	Starch Equivalent (lb).	Protein Equivalent (lb.).
3·5–3·8	2·50	0·60
3·9–4·0	2·60	0·63
4·1–4·3	2·75	0·67
4·4–4·6	2·87	0·70
4·7–4·9	3·00	0·75
5·0–5·1	3·10	0·77
5·2–5·3	3·25	0·80

The above standards have been used in calculating the dairy-cow rations given in this book.

For calculating the maintenance requirement of the different breeds of cows, and the production requirements per gallon of milk, the following table will prove useful:

Breed of Cow.	Average Live Weight. (lb.)	Average per cent of Fat in Milk.	Maintenance Starch Equivalent Requirement per day (lb.).	Maintenance Protein Equivalent Requirement per day (lb.).
South Devon ..	1,450	4·0	7·6	0·86
Lincoln Red ..	1,300	3·8	7·1	0·77
Longhorn	1,300	3·8	7·1	0·77
Dairy Shorthorn ..	1,250	3·7	6·9	0·74
British Friesian ..	1,250	3·7	6·9	0·74
Blue Albion ..	1,150	3·7	6·6	0·68
Welsh Black ..	1,150	3·8	6·6	0·68
Devon	1,150	4·2	6·6	0·68
Red Poll	1,100	3·8	6·4	0·65
Ayrshire	1,000	4·0	6·0	0·60
Guernsey	950	5·0	5·8	0·57
Kerry	850	4·7	5·3	0·51
Jersey	800	5·2	5·1	0·48
Dexter	650	3·7	4·4	0·39

The above standards are based on the recommendations of a Departmental Committee on the Rationing of Dairy Cows appointed by the Ministry of Agriculture and Fisheries in 1924, but since that date evidence has accumulated to indicate that the standards at present in use are on the generous side. In 1929 Halnan, after carefully reviewing the existing literature on the subject, came to the conclusion that 5 lb. of starch equivalent was adequate for the daily

maintenance of a 1,000-lb. cow, the maintenance requirement for protein being 0·6 lb. protein equivalent. For the production of a gallon of 4% fat milk 2·5 lb. starch equivalent containing 0·48 lb. of digestible pure protein, or 0·57 lb. protein equivalent was suggested. The margin of difference between the figure for digestible pure protein and protein equivalent is much larger than it should be, since the percentage of non-protein nitrogen in feeding-stuffs used in milk production mixtures is much smaller than that in feeding-stuffs used for maintenance. Allowing for this fact, a standard of 0·48 lb. digestible pure protein or 0·5 lb. of protein equivalent would be nearer the truth. In a large-scale experiment organized by the National Institute of Reading and quoted by Mackintosh, 1,400 cows were fed on two rations, half on a ration containing 0·6 lb. protein equivalent per 10 lb. of milk, and half on a ration containing two-thirds this amount. The lower protein ration was as effective as that containing the higher amount and Mackintosh accordingly adopts the standard of 0·5 lb. protein equivalent as the requirement for 10 lb. of average quality milk. It is interesting to note that this lower standard is also in accordance with the estimate of 0·48 lb. digestible pure protein per gallon of milk quoted above.

A Simplified Method of Calculating Balanced Mixtures for Milk Production.

In working out balanced mixtures suitable for milk production, the farmer or student first has to calculate from the table of compositions a mixture of feeding-stuffs whose ratio of protein equivalent to starch equivalent agrees with that for milk of average composition, i.e., 0·6 or 0·5 P.E. to 2·5 S.E., and then, by simple arithmetic, he has to calculate the number of pounds of the mixture to feed to produce each gallon of milk. The methods of calculation are not easy, since it means formulating a mixture which it is anticipated will be nearly balanced, working out the protein equivalent and starch equivalent of this mixture, and then making adjustments until the proper balance is achieved. It is for this reason that authors of books or bulletins dealing with feeding standards usually give a series of mixtures suitably balanced for milk production. Indeed, this plan has already been adopted in this book, but it has the disadvantage that the average reader is unable to take full advantage of the data given in the feeding-stuffs table of compositions, and discourages him from attempting to formulate rations himself. In order to overcome this difficulty a new plan of presenting the data

required in a table of compositions of feeding-stuffs used for milk production was evolved. The plan consists in presenting, not the protein equivalent and the starch equivalent present in each pound of the feeding-stuff, but the milk-producing value of the protein equivalent and the starch equivalent in each pound of the feeding-stuff. The milk-producing value for protein equivalent is obtained by dividing the protein equivalent in a pound of the feeding-stuff by the protein equivalent required to produce a gallon of milk, and the milk-producing value for starch equivalent is similarly obtained by dividing the starch equivalent in a pound of the feeding-stuff by the starch equivalent required to produce a gallon of milk. Two sets of figures are thus obtained, one giving the amount of milk in gallons that the protein equivalent in the feeding-stuff would provide for so far as the protein portion of the milk is concerned, and the other similar figures so far as the starch equivalent is concerned. The table of compositions that follows has been obtained by following this procedure, and for the sake of convenience to farmers and students, two sets of data are presented, one based on milk of 3·7% composition, and the other on milk of 5% fat composition. The latter set of figures would be suitable for calculating balanced milk mixtures for Guernseys and Jerseys, the former for Shorthorns, British Friesians, and other breeds.

For the calculation of milk-production requirements for Jerseys and Guernseys use Columns A.1 and B.1, for all other breeds use columns A. and B. The figure 0·5 lb. protein equivalent per gallon of average milk is used in calculating the above figures, and not the hitherto accepted figure of 0·6.

Method of Use of Table for Constructing Mixtures Balanced for Milk Production.

Since the figures given in Column A represent the gallons of milk that the protein equivalent in 1 lb. of the feeding-stuff will produce so far as its protein content is concerned, and since the figures given in Column B give similar data so far as the starch equivalent content of the milk is concerned, it follows that a mixture is balanced for milk production if the number of lb. of the feeding-stuffs used in the mixture multiplied by the appropriate figures in Column A and Column B give the same result. In order to make the position quite clear, two examples of working are given; in the first, a balanced mixture is worked out using two feeding-stuffs, in the second, more than two feeding-stuffs are employed.

TABLE OF COMPOSITION OF FEEDING-STUFFS

(Giving the amounts of milk, in gallons, provided for, in the form of starch equivalent and protein equivalent, by each pound of the feeding-stuff.)

Feeding-stuff.	Gallons Milk, as Protein Equivalent.		Gallons Milk, as Starch Equivalent.	
	A.	A.1.	B.	B.1.
Barley	·0·15	0·12	0·28	0·22
Beans	0·39	0·31	0·26	0·20
Brewers' grains (dried)	0·25	0·20	0·19	0·15
Brewers' grains (wet)	0·11	0·09	0·07	0·06
Coconut cake	0·33	0·26	0·31	0·24
Cotton cake (decorticated)	0 69	0·54	0·27	0·21
Cotton cake (undecorticated), Bombay	0·30	0·24	0·16	0·13
Cotton cake (undecorticated), Egyptian	0·35	0·28	0·17	0·13
Distillers' grains (dried)	0·38	0·30	0·23	0·18
Fish meal	1·06	0·84	0·23	0·18
Ground-nut cake (decorticated)	0·83	0·65	0·29	0·23
Ground-nut cake (undecorticated)	0·54	0·43	0·23	0·18
Linseed	0·37	0·29	0·48	0·38
Linseed cake	0·49	0·39	0·30	0·24
Locust beans	0·07	0·06	0·28	0·22
Maize	0·15	0·12	0·31	0·24
Maize, flaked	0·18	0·14	0·34	0·27
Maize germ meal	0·21	0·17	0·34	0·27
Maize gluten feed	0·38	0·30	0·30	0·24
Malt culms	0·32	0·25	0·17	0·13
Meat meal (high fat)	0·99	0·78	0·29	0·23
Meat meal (low fat)	1·02	0·80	0·24	0·19
Meat and bone meal	0·68	0·54	0·27	0·21
Oats	0·15	0·12	0·24	0·19
Palm-nut kernel cake	0·34	0·27	0·29	0·23
Palm-nut kernel cake (fat extracted)	0·33	0·26	0·28	0·22
Peas	0·36	0·28	0·28	0·22
Rice meal (pollard)	0·14	0·11	0·29	0·23
Rye	0·18	0·14	0·29	0·23
Sesame cake	0·78	0·61	0·29	0·23
Soya-bean cake	0·74	0·58	0·28	0·22
Soya-bean meal (extract)	0·77	0·61	0·26	0·21
Sugar-beet pulp (dried)	0·10	0·08	0·24	0·19
Sugar-beet pulp (molassed)	0·09	0·07	0·23	0·18
Sunflower cake (decorticated)	0·64	0·50	0·29	0·23
Sunflower cake (undecorticated)	0·33	0·26	0·20	0·16
Treacle	0·08	0·06	0·20	0·16
Whale meat meal	0·99	0·78	0·32	0·25
Wheat	0·17	0·13	0·29	0·23
Wheat bran	0·24	0·19	0·24	0·19
Wheat middlings (coarse)	0·26	0·21	0·27	0·22
Wheat middlings (fine)	0·15	0·12	0·33	0·26
Weatings	0·25	0·20	0·27	0·22
Weatings (Superfine)	0·26	0·21	0·29	0·24
Yeast (dried)	0·81	0·64	0·27	0·21

Case 1. *To obtain a Balanced Mixture using Two Foods.*

Foods that are unbalanced for milk production will either contain too much protein equivalent or too much starch equivalent. It follows from this that if it is desired to construct a balanced mixture from two feeding-stuffs one of the feeding-stuffs must contain an excessive amount of protein equivalent and the other an excessive amount of starch equivalent. From the above table we select two feeding-stuffs which satisfy this condition, for example, bean meal and crushed oats.

Example.—We are required to find how much bean meal to add to 1 lb. of crushed oats to obtain a balanced mixture. Let x represent the amount of bean meal required.

Now Protein equivalent gals. = Starch equivalent gals. when the mixture is balanced for milk production.

Therefore $1 \times$ crushed oats protein equivalent gals. $+ x \times$ bean meal protein equivalent gals. $= 1 \times$ crushed oats starch equivalent gals. $+ x \times$ bean meal starch equivalent gals.

Substituting from the table of compositions we get:

$$1 \times 0{\cdot}15 + x \times 0{\cdot}39 = 1 \times 0{\cdot}24 + x \times 0{\cdot}26$$
$$\text{That is } (0{\cdot}39 - 0{\cdot}26)\, x = 0{\cdot}24 - 0{\cdot}15$$
$$\text{Therefore } 0{\cdot}13\, x = 0{\cdot}09$$
$$\text{Whence } x = 0{\cdot}7 \text{ (approximately).}$$

That is to say, the balanced mixture is 1 lb. of crushed oats to 0·7 lb. bean meal, or 10 lb. of crushed oats and 7 lb. of bean meal.

To ascertain the number of pounds of this mixture required per gallon of milk is also simple: it is done by taking the figures in either Column A or Column B of the table of composition and multiplying by the pounds of each food used in the mixture. This gives the number of gallons of milk the mixture will produce.

Thus, in the example above, 17 lb. of the mixture contains 10 lb. crushed oats and 7 lb. bean meal.

Substituting the figures in Column A we get $10 \times 0{\cdot}15 + 7 \times 0{\cdot}39 = 4{\cdot}23$ gallons milk; i.e., 4·23 gallons milk require 17 lb. of mixture.

Therefore 1 gallon of milk requires 4 lb. approximately. That is to say, 4 lb. of the mixture would be fed for each expected gallon of milk.

Case 2. *To obtain a Balanced Mixture using more than Two Foods.*

When more than two foods are used, all the foods except one are mixed in any desired proportion, and the protein equivalent and the starch equivalent gallons per pound of the resultant mixture worked out from the composition figures of the separate ingredients. This

is then equated with the remaining food as in Case 1, care of course being taken to see that if the foods mixed in the first instance contain an excess of starch equivalent, the remaining food contains an excess of protein equivalent, and *vice versa*.

Example.—To obtain a balanced mixture using bran, coarse middlings, flaked maize and decorticated ground-nut cake. It is decided to mix the bran, middlings and flaked maize in the following proportions: bran, 2 parts; middlings, 2 parts; flaked maize, 1 part.

From the table of composition:

	Gallons P.E.		Gallons S.E.
2 parts bran yield	$2 \times 0{\cdot}24 = 0{\cdot}48$	and	$2 \times 0{\cdot}24 = 0{\cdot}48$
2 parts coarse middlings yield	$2 \times 0{\cdot}26 = 0{\cdot}52$	,,	$2 \times 0{\cdot}27 = 0{\cdot}54$
1 part flaked maize yields	$1 \times 0{\cdot}18 = 0{\cdot}18$	,,	$1 \times 0{\cdot}34 = 0{\cdot}34$
Therefore 5 lb. of mixture	$= 1{\cdot}18$	,,	$= 1{\cdot}36$
Therefore 1 lb. of mixture	$= 0{\cdot}24$	,,	$= 0{\cdot}27$

Equating 1 lb. of the mixture with x lb. of decorticated ground-nut cake we get:

$$1 \times 0{\cdot}24 + x \times 0{\cdot}83 = 1 \times 0{\cdot}27 + x \times 0{\cdot}29$$
$$\text{Whence } (0{\cdot}83 - 0{\cdot}29)x = 0{\cdot}27 - 0{\cdot}24$$
$$\text{Whence } 0{\cdot}56\,x = 0{\cdot}03$$
$$\text{i.e. } x = 0{\cdot}05 \text{ (approximately).}$$

Therefore the mixture will be 5 lb. of decorticated ground-nut cake to every 100 lb. of the cereal mixture. The final mixture thus becomes:

40 lb. Bran.
40 lb. Coarse middlings.
20 lb. Flaked maize.
5 lb. Decorticated ground-nut cake.

To find the number of pounds of mixture required per gallon of milk produced:

105 lb. of the mixture will give $100 \times 0{\cdot}24 + 5 \times 0{\cdot}83$ gallons $= 24 + 4{\cdot}15 = 28{\cdot}2$ approximately.

The number of pounds of food per gallon will, therefore, be $105 \div 28{\cdot}2 = 3$ lb. 12 oz. approximately.

Feeding Standards for Fattening Cattle.

In calculating rations for cattle, the principal cases likely to be met with are (1) rationing of store or fattening cattle during the winter months, (2) rationing of store or fattening cattle on grass in summer.

The table that follows gives all the data from which the theoretical requirements can be calculated; these are taken from the standards

given in the Ministry of Agriculture's Bulletin No. 48, and are here reproduced by permission of the Controller, H.M. Stationery Office.

Live Weight of Animal cwt.	Appetite. Dry-Matter per day.	Maintenance Requirement per day Starch Equivalent.	Protein Equivalent required per day for Maintenance plus Production.
	lb.	lb.	lb.
5	14½	4	1¼
6	17	4½	1¼
7	19	5	1⅓
8	20½	5½	1⅓
9	22	6	1½
10	23½	6½	1½
11	25	7	1½
12	26½	7½	1½
13	28	7¾	1½
14	29½	8¼	1½
15	31	8½	1½
16	32½	8¾	1½

Age and Condition of Animal.		Starch Equivalent in excess of Maintenance to produce 1 lb. Live-Weight Increase.
Under 2 years—	Stores	2
	Fresh Condition	2¼
About 2 years—	Stores	2¼
	Fresh condition	2½
Over 2 years—	Stores	2½
	Fresh condition	2¾
	Half fat	3
	Fat	4

Method of Use of the Table.

By means of the data given in this table and in Table III in the Appendix, it is possible to calculate a ration for any given set of conditions.

Example.—To winter fatten a 9 cwt. bullock over two years of age. Estimated daily live-weight increase, 2 lb. per day. Feeding-stuffs available: Meadow hay (good average), swedes, and linseed cake.

From the table given above it will be seen that the theoretical requirements are:

	S.E. (lb.).	P.E. (lb.).
For maintenance	6·0	—
For maintenance and production	—	1·5
For 2 lb. daily increase in live weight	5·5	—
Total	11·5	1·5

The ration must therefore contain 11·5 lb. of S.E. and 1·5 lb. P.E., and must not exceed 22 lb. dry matter.

Assuming that two bushels a day of swedes and 12 lb. of meadow hay are given, we can calculate from the figures in the appropriate columns of Table III, Appendix, the S.E. dry matter, and P.E. supplied by these ingredients.

	S.E. (lb.)	P.E. (lb.)	Dry Matter. (lb.)
2 bushels swedes (90 lb.)	6·53	0·63	10·35
12 lb. hay	3·72	0·55	10·28
Total ..	10·25	1·18	20·63

The ration as designed is still short of requirements and the figures indicate the need for a high protein concentrate. To satisfy the protein need approximately 1¾ lb. of linseed cake would be required. Adding this to the swedes and hay we get the following figures:

	S.E. (lb.)	P.E. (lb.)	Dry Matter. (lb.)
From swedes and hay	10·25	1·18	20·63
From 1¾ lb. linseed cake	1·30	0·43	1·55
Total ..	11·55	1·61	22·18

A daily ration of 90 lb. swedes, 12 lb. hay, and 1¾ lb. linseed cake will therefore be suitable for the winter fattening of a 9 cwt. bullock, and should produce a daily live-weight increase of 2 lb.

Rationing Cattle on Grass.

If computations are made from the figures given in Table III, Appendix, for the S.E. and P.E. content of grass, assuming that the animal consumes sufficient grass to reach its appetite (dry matter) requirement, it will become evident that the grass alone will suffice both for maintenance and for the production of 1 to 3 lb. daily live-weight increase. In searching for its food, a certain amount of muscular energy is expended, so that the maintenance S.E. figures are above those given in the table, which are based on open yard or stall fattening conditions. No accurate estimates of the amount of energy expended in grazing are available, but it is usually accepted that the animal requires 1 lb. of S.E. extra for this purpose if grazing on good

fattening pasture, 2 lb. S.E. when grazing on good pasture, and 3 lb. S.E. per day when grazing on poor pasture.

Feeding Standards for Horses.

In fixing a feeding standard for working horses, it is essential to realize that such a standard is of value mainly as a rough working guide, and that the estimates given by various authorities show wide divergence. After careful consideration, it was decided that the estimates given by R. G. Linton conform most closely to English conditions and have consequently been adopted with minor modifications as a standard. The standards are:

	Starch Equivalent. lb.	Digestible Protein lb.
For the daily maintenance of a 1,000 lb. horse	5·0	0·5
Add or deduct for every 100 lb. live weight over or below 1,000 lb.	0·3	0·05
For every hour of hard work ..	1·0	0·20

Careful attention needs to be paid to the amount of coarse fodder such as hay included in the ration. As a general working rule, the requirements for maintenance should be supplied to a large extent from coarse fodders, the requirements for work from concentrates. If too large an amount of bulky fodder is given to a horse in hard work its efficiency is impaired. Consequently the need for considering the bulk of the total ration is of importance. Linton estimates that the total dry matter of the daily ration of a working horse should lie within the limits of 1·5 to 2% of the animal's live weight, and within 1 to 1·25% of its live weight when in idleness.

In fixing the requirements for work, only the time when the horse is actually working should be counted, the time during which the horse is resting being ignored.

Rations are often given for horses doing light, medium, or heavy work. It is obviously impossible to define these classes of work in precise terms, but a good working rule will be to regard light work as constituting 3 hours of hard work a day, medium work as 5 hours a day, and hard work as 7 hours a day. (At harvest, of course, longers hours will be worked.)

Mares Suckling Foals.

For mares suckling foals a suitable standard per 1,000 lb. live

weight will be 1·3 lb. D.P. and 8·2 lb. S.E., adding for every 100 lb. live weight above 1,000 lb. 0·1 lb. D.P. and 0·6 lb. S.E. If the mare is doing light work, add in addition 0·6 lb. D.P. and 3·0 lb. S.E. The dry matter of the total ration should approximate to 1·5% of the mare's live weight.

FEEDING-STUFFS TABLE FOR HORSES, (PARTS PER 100).

	Dry Matter.	Digestible Crude Protein.	Nutritive Ratio.	Starch Equivalent.	Hay Equivalent.	Oat Equivalent.
Meadow hay ..	85·7	5·5	1 : 6·1	31	100	—
Dried grass ..	90·0	10·9	1 : 3·8	45	68	—
Clover hay ..	83·5	7·6	1 : 4·1	34	91	—
Lucerne hay ..	83·5	11·8	1 : 2·8	33	94	—
Seeds hay ..	86·0	6·7	1 : 5·0	32	97	—
Oat straw ..	86·0	1·0	1 : 29·0	19	163	—
Barley ..	85·1	8·0	1 : 8·0	70	—	83
Beans	85·7	21·8	1 : 2·3	69	—	84
Brewers' grains	89·7	14·2	1 : 2·4	39	—	149
Maize	87·0	7·7	1 : 9·5	80	—	72
Oats	86·7	8·9	1 : 6·0	58	—	100
Peas	86·0	18·7	1 : 2·6	64	—	90
Linseed cake ..	88·8	24·0	1 : 1·9	67	—	87
Bran	87·0	12·6	1 : 2·6	34	—	170
Carrots ..	13·0	1·2	1 : 7·3	10	—	580
Mangolds ..	13·2	0·7	1 : 14·0	7	—	830
Swedes ..	11·5	1·1	1 : 7·5	7	—	830

The last two columns give the amounts of the food in question equivalent to 100 lb. of hay or oats, from the starch equivalent standpoint.

Method of Use of the Tables.

The feeding standards, in conjunction with the table of data, can be used for calculating rations for any given purpose.

Example 1.—A heavy draft horse (1,680 lb.) doing heavy transport work at walking pace (6 hours).

Requirements.	S.E.	Digestible Crude Protein.
For maintenance		
1,000 lb.	5·0	0·5
680 lb. (0·3 × 6·8)	2·04	0·34 (0·05 × 6·8)
For work (6 hours)		
(6 × 1 × 1·68)	10·08	2·02 (6 × 0·2 × 1·68)
Total	17·12	2·86

Suggested Ration.	S.E.	Digestible Crude Protein.	Dry Matter.
18 lb. meadow hay ..	5·58	0·99	15·42
1 lb. beans..	0·69	0·22	0·86
19 lb. oats	11·02	1·69	16·47
Total ..	17·29	2·90	32·75

Dry matter = 1·9% of body weight.

Example 2.—Same horse, in idleness.

Requirements.	S.E.	Digestible Crude Protein.
For maintenance	7·04	0·84

Suggested Ration.	S.E.	Digestible Crude Protein.	Dry Matter.
12 lb. meadow hay ..	3·72	0·66	10·28
14 lb. oat straw	2·66	0·14	12·04
10 lb. swedes	0·70	0·11	1·15
Total ..	7·08	0·91	23·47

Dry matter = 1·4% of body weight.

N.B.—In actual practice, 4 to 6 lb. of the above fodders will be fed as chaff, or some chaff added, to ensure adequate mastication.

Pig Feeding Standards.

In the case of pig feeding, the standards can be simplified owing to the fact that the foods used are all of the same character, and owing to the fact that, since the object of the fattener is to get the desired weight in the least possible time, there is no essential need to differentiate between the maintenance and the production requirement. Moreover, if the starch equivalent requirement of the fattening pig at different live weights is divided by the daily appetite requirement expressed in terms of meal, it will be found that the starch equivalent of a pig meal fluctuates between 71% and 75% from live weights of 80 lb. and upwards. Below this live weight the starch equivalent values are much higher, provision for this extra demand

is best catered for by using whey or milk in conjunction with the usual pig meal mixture. The constancy of the desired starch equivalent content in pig meals intended for fattening pigs from live weights of 80 lb. upwards enables us to state the requirements of pigs in terms of meal, using barley meal as our standard, and stating for all other foods the amount of that food equivalent to 10 lb. of barley meal. Moreover, since the majority of the foods used for fattening pigs have starch equivalents varying from 70 to 75% substitution of one food for another in a pig meal within reason is not likely seriously to disturb the starch equivalent of the mixed meal. The lessened requirement of starch equivalent for pigs intended for breeding is met by stating a reduced daily allowance of meal.

One other point of importance in pork and bacon production is the effect of the food on the quality of the product, especially on the fat. This effect is much more marked in the case of rapid fattening, since under such circumstances the food fat forms a larger proportion of the body fat than is the case when fattening proceeds slowly. Since the effect of the food on the quality of the product is so important, an indication of this effect is given in the tables.

FEEDING STANDARDS FOR PIGS, IN TERMS OF DAILY REQUIREMENTS PER HEAD OF DIGESTIBLE CRUDE PROTEIN AND MEAL

Live Weight. (in lb.)	Meal (in lb.)		Digestible Crude Protein. (lb.)	Starch Equivalent per 100 lb. Meal.
	Breeding Stock.	Fattening Stock.		
40	1·9	1·9	0·30	93
60	2·7	2·7	0·35	88
80	3·5	3·5	0·44	75
100	4·0	4·1	0·49	73
140	5·1	5·3	0·58	71
180	6·8	6·3	0·64	73
200	6·1	6·8	0·66	72
240	6·7	7·5	0·68	72
280	7·0	7·9	0·67	73
320	7·3	8·2	0·65	73

In-pig sows, 4·4–7·4, according to amount of grazing available and condition of sow. Digestible crude protein, 0·5 to 0·7 lb.

Sows with litter, 9·0–20·0 lb. meal according to size of litter and time from farrowing, containing 1·0–1·5 lb. digestible crude protein, the lower quantities being required when the sow is out at grass or receiving succulents. During the first week after farrowing the meal should consist of coarse middlings only.

FEEDING-STUFFS TABLE FOR PIGS

	Digestible Crude Protein per lb.	Lb. of Food Equivalent to 1 lb. of Meal.	Effect on Quality of Product.
Succulents.			
Artichokes	0·010	4·3	Good
Cabbage	0·018	7·4	Good
Carrots	0·009	6·5	Good
Clover	0·023	10·0	Good
Grass (young)	0·049	6·5	Good
Kale (marrow stem)	0·017	7·7	Good
Kale (thousand head)	0·017	6·8	Good
Kohl rabi	0·007	8·5	Good
Lucerne	0·030	8·0	Good
Mangold	0·007	10·3	Good
Potatoes (steamed)	0·011	3·4	Excellent
Sugar beet	0·008	3·3	Good
Swede turnip	0·010	7·3	Good
Turnips	0·008	10·0	Good
Watery Concentrates.			
Brewers' grains	0·048	5·4	Not known
Buttermilk	0·034	7·7	Good
Milk (skim)	0·032	8·3	Excellent
Milk (whole)	0·032	4·0	Excellent
Whey	0·006	12·0	Good
Concentrates.			
Digestible crude protein 0·0–0·05			
Acorns	0·027	1·7	Not known
Sago-pith meal	0·000	1·1	Not known
Sugar-beet pulp (dried)	0·034	1·1	Good
Sugar-beet pulp (molassed)	0·026	1·1	Good
Tapioca flour	0·012	0·8	Good
Digestible crude protein 0·05–0·16			
Barley meal	0·082	1·0	Very good
Brewers' grains (dried)	0·130	1·5	Moderate
Buckwheat	0·075	1·3	Not known
Dari (as meal)	0·076	1·0	Good
Lucerne meal (bud stage)	0·159	1·4	Not known
Lucerne meal (flower stage)	0·116	1·6	Not known
Maize meal	0·079	0·9	Good in moderation, bad in excess
Maize (flaked)	0·089	0·8	As for maize
Middlings (fine)	0·137	1·1	Good
Middlings (coarse)	0·128	1·3	Moderately good

FEEDING-STUFFS TABLE FOR PIGS—(*cont.*)

	Digestible Crude Protein per lb.	Lb. of Food Equivalent to 1 lb. of Meal.	Effect on Quality of Product.
Oats (finely ground)	0·088	1·2	Good
Rice bran or meal	0·075	1·0	Bad
Rye meal	0·096	1·0	Good
Wheat (ground)	0·102	1·0	Good
Whey (dried)	0·122	0·8	Good
Coconut cake meal	0·142	1·1	Very good
Digestible crude protein 0·16–0·31			
Bean meal	0·203	1·0	Good
Ground-nut cake meal (undecorticated)	0·277	1·2	Poor
Ground-nut cake meal (undecorticated extracted)	0·292	1·6	Moderately good
Linseed cake meal	0·255	1·1	Bad
Linseed cake meal (extracted) ..	0·308	1·1	Poor
Maize-gluten feed	0·200	1·0	Not known
Maize-gluten meal	0·306	0·9	Not known
Milk (dried skim)	0·295	0·9	Excellent
Milk (dried whole)	0·240	0·6	Excellent
Palm-nut kernel meal	0·175	1·0	Very good
Palm-nut kernel meal (extracted)	0·171	1·0	Very good
Pea meal	0·180	1·1	Very good
Digestible crude protein 0·31–0·46			
Ground-nut meal (extracted decorticated)	0·420	1·0	Good
Meat and bone meal	0·392	1·0	Good
Soya-bean meal (extracted) ..	0·403	1·1	Good
Yeast (dried)	0·444	1·1	Not known
Digestible crude protein 0·46–0·61			
Buttermilk (dried)	0·468	1·0	Good
Fish meal (white)	0·550	1·2	Good in small amount
Meat meal (60% protein) ..	0·468	1·0	Good
Whale meat meal	0·640	0·8	Not known
Digestible crude protein 0·61–0·76			
Blood meal	0·727	1·1	Not known
Meat meal (pure)	0·672	0·8	Good

Note.—If, in substituting feeding-stuffs, those placed in the same protein class are used, the digestible crude protein content of the ration will not be seriously affected.

Application of Standards.

The rationing of pigs, particularly those intended for baconers, can be expressed in simple terms, using barley meal, middlings, and fish meal or a suitable protein concentrate mixture as ingredients. Such a scheme of rationing would be as follows:

	Middlings. lb.	Barley Meal. lb.	Fish Meal or Protein Concentrate Mixture. lb.
Breeding sows up to farrowing, and stock boars	70	25	5
Breeding sows with litters—			
1st week	100	—	—
2nd week	90	—	10
3rd week	80	10	10
4th week to one week after weaning	65	25	10
Changing gradually to, at end end of 13th week	35	55	10
From 14th week to last 4 weeks of fattening	20	70	10
Changing gradually to, at last two weeks of fattening for bacon, or for fattening boars or sows ..	20	80	—

Substitution of Foods.

Fish meal may be substituted by any of the foods in the same protein class in the table in accordance with the meal equivalent table. Other protein rich foods should be substituted in accordance with their protein content. A good protein concentrate mixture that has given excellent results is:

1 cwt. Extracted soya-bean meal, or ground-nut meal.
7 lb. Dried yeast.
14 lb. Ground chalk or limestone flour.
7 lb. Steam bone flour.
3½ lb. Common salt.

This mixture may replace fish meal on a pound-for-pound basis.

During the winter months, i.e. from mid-September to mid-April, 2% of cod liver oil is recommended for all classes of stock except baconers. This is achieved by adding 20% of cod liver oil to the protein concentrate mixture. If white fish meal is used as the concentrate, or if milk is given, the addition of cod liver oil is unnecessary.

Up to 30% of the middlings can be replaced by coconut cake meal or maize gluten feed or meal from the tenth week onwards for pigs intended for baconers.

Up to 40% of the barley meal can be substituted by ground cereals or tapioca flour mixtures from the tenth week onwards in the case of baconers, and up to 25% by dried sugar-beet pulp or molassed beet pulp.

Barley meal may be freely substituted by steamed potatoes up to 8 lb. daily, in accordance with their meal equivalents.

In the case of breeding stock, or store pigs, free substitution with discretion may be exercised for all the feeding-stuffs given in the table.

Feeding Standards for Poultry.

Although estimates have been made of the protein and energy requirements of chicks, they possess a theoretical rather than a practical interest, since in the case of chick rations the qualitative factors of the diet are of more importance than quantitative considerations of the exact amounts of protein and energy to feed. These factors have been fully considered in drawing up the rations given in the chapter on the feeding of poultry. Moreover, the proportion of protein to energy in chick dietaries can vary considerably without materially affecting the final result. Thus the crude protein varies in successful chick dietaries from 15 to 21%. When high protein levels are fed the effect is to quicken up growth in the chicks and to slow it down when the growers' stage is reached, when low protein levels are fed the reverse occurs. Indeed, the amount of fibre in the chick's ration is of more importance than the exact amounts of protein and energy, since if high fibre-containing diets are used the growth of the chicks is considerably impeded. As a rough working rule, in compounding rations for poultry a fibre content not lower than 4% and not higher than 6·5% should be aimed at. The amount of calcium and phosphorus in chick diets is also of primary importance. The calcium to phosphorus ratio should be 1·6 to 1, the ideal levels being 0·7% of phosphorus and 1·1% calcium. The phosphorus content can vary between 0·5 to 1·2%, the calcium content being varied to keep the calcium-phosphorus ratio at the level indicated above. The manganese content of the ration should also be at least 50 parts per million parts of the ration. The minimum vitamin content of the chick's diet should be as follows:

Vitamin A—1,450 international units per lb. of ration.
Vitamin B1—180 international units per lb.
Vitamin B2 (Vitamin G)—1,670 micrograms[1] ribo-flavin per lb.
Vitamin D3—180 international units per lb.

[1] 1 microgram = 1-millionth of a gram.

For egg production the recommended vitamin content of the ration per lb. is :

Vitamin A—3,150 international units.
Vitamin B1—180 international units.
Vitamin B2—680 micrograms.
Vitamin D3—360 international units.

For the production of hatching eggs, the recommended vitamin content of the ration per lb. is :

Vitamin A—4,720 international units.
Vitamin B1—180 international units.
Vitamin B2—1250 micrograms.
Vitamin D3—540 international units.

In the case of laying-stock, the amounts of protein and energy required for maintenance and for egg production are of greater significance, since the amounts of food consumed by laying-stock are large, and waste will result if the feeding is not controlled. On the other hand, birds are not fed individually but in flocks, it is therefore not possible to exercise such rigid control as is possible in the case of the dairy cow.

The most recent estimates of the protein and energy requirements of the egg-producing fowl are:

1. DAILY REQUIREMENTS FOR MAINTENANCE, IN GRAMS.

Weight of Bird in lb.	Digestible Protein.	Starch Equivalent.
3	1·9	47·5
4	2·5	51·8
5	3·1	56·0
6	3·7	60·2

2. REQUIREMENTS FOR THE PRODUCTION OF A 2-OUNCE EGG, IN GRAMS.

Digestible protein, 12·5. Starch equivalent, 38·0.

In view of the differences between the digestibilities of feeding-stuffs as ascertained on the ruminant and on the fowl, the usual tables of composition given in the Appendix cannot be applied to poultry. In addition, the usual method of expressing the phosphorus and the calcium contents of feeding-stuffs as oxides is not readily applied to poultry.

In the table that follows, the starch equivalent figures are calculated on poultry digestibility determinations, and the calcium and phosphorus figures are expressed as calcium or phosphorus and not as their oxides. In addition, owing to the impossibility of determining the digestibility of the protein in the fowl by direct means, coupled with the fact that ordinary determinations of the digestibility of the protein of feeding-stuffs give the *apparent digestibility* of the protein and not the *true digestibility*, it was decided to utilize the protein digestibility figures as ascertained by in-vitro methods. Egg produc-

POULTRY FEEDING-STUFFS TABLE

	Proportion per Unit of Weight.		Mineral Content, parts by Weight per 100 of Feeding-stuff.			Egg Production Data. No. of 2-oz Eggs provided for in 1 lb. of Meal.	
	Digestible Protein. (1)	S.E. (2)	Calcium. (3)	Phosphorus. (4)	Chlorine. (5)	In D.P. (6)	In S.E. (7)
Alfalfa meal	0·108	0·226	1·799	0·284	0·92	3·9	2·70
Barley and meal	0·076	0·651	0·036	0·336	0·02	2·8	7·77
Beans and meal*	0·222	0·659	0·114	0·528	0·05	8·1	7·87
Biscuit meal	0·119	0·834	0·093	0·227	0·08	4·3	9·96
Blood meal	0·795	0·773	0·107	0·153	0·68	28·9	9·23
Buckwheat	0·091	0·603	0·086	0·581	0·04	3·3	7·20
Buttermilk (dried)	0·413	0·788	1·928	1·441	1·97	15·0	9·41
Cabbage*	0·009	0·059	0·143	0·065	0·10	0·3	0·70
Coconut-cake meal*	0·175	0·672	0·357	0·655	0·13	6·4	8·02
Cotton-seed meal	0·369	0·705	0·243	1·214	0·03	13·4	8·42
Dari	0·090	0·806	0·036	0·388	trace	3·3	9·62
Earthnut cake meal	0·439	0·743	0·485	0·677	0·014	15·9	8·87
Fish meal	0·474	0·543	7·497	2·751	0·60	17·2	6·48
Groats	0·155	0·869	0·057	0·402	trace	5·6	10·37
Hempseed*	0·198	0·846	0·136	0·860	trace	7·2	10·10
Insects (dried)*	0·335	0·515	—	—	—	12·2	6·15
Linseed and meal*	0·192	1·024	0·214	0·611	0·86	7·0	12·23
Maize and meal	0·087	0·766	0·007	0·275	0·0001	3·2	9·15
Maize (flaked)	0·092	0·857	0·007	0·275	0·0001	3·3	10·23
Maize-gluten feed*	0·188	0·741	0·071	0·305	0·04	6·8	8·85
Maize-gluten meal*	0·304	0·813	0·071	0·087	0·01	11·0	9·71
Meat meal	0·639	0·867	0·285	0·305	0·12	23·2	10·35
Meat and bone meal	0·464	0·661	8·104	3·938	0·46	16·9	7·89
Millet (Bulrush)	0·119	0·786	0·014	0·327	0·02	4·3	9·38

Milk (fresh)*	0·033	0·163	0·121	0·096	0·12	1·2	1·95
Milk (dried whole)*	0·245	1·175	1·321	0·886	1·21	8·9	14·03
Milk (dried skim)*	0·314	0·764	1·185	0·947	1·20	11·4	9·12
Pasture grass	0·042	0·133	0·178	0·083	0·42	1·5	1·59
Oats and S.G.O.	0·092	0·589	0·086	0·340	0·05	3·3	7·03
Peas and meal	0·198	0·674	0·086	0·393	0·04	7·2	8·05
Palm-kernel-cake meal* ..	0·157	0·635	0·214	0·480	0·02	5·7	7·58
Potatoes	0·016	0·181	0·021	0·061	0·03	0·6	2·16
Rice (whole)	0·063	0·651	0·021	0·170	trace	2·3	7·77
Rice (hulled)	0·085	0·849	—	—	—	3·1	10·14
Rice (polished)	0·081	0·837	0·007	0·087	0·05	2·9	9·99
Rice meal	0·106	0·841	0·071	1·135	trace	3·8	10·04
Rye	0·100	0·695	0·050	0·353	0·02	3·6	8·30
Soya-bean meal (extd.)	0·419	0·678	0·214	1·000	0·07	15·2	8·09
Sunflower-seed cake*	0·314	0·627	0·385	0·939	0·01	11·4	7·49
Sugar-beet pulp (molassed) ..	0·076	0·234	0·878	0·083	0·28	2·8	2·79
Wheat (strong varieties) ..	0·116	0·752	0·043	0·406	0·06	4·2	8·98
Wheat (weak varieties)	0·083	0·749	0·043	0·406	0·06	3·0	8·94
Wheat bran	0·128	0·371	0·114	1·148	0·09	4·6	4·43
Wheat middlings (fine)	0·072	0·755	0·050	0·655	0·001	2·6	9·01
Wheat middlings (coarse) ..	0·142	0·571	0·071	1·135	0·03	5·2	6·82
Weatings	0·135	0·562	0·071	1·135	0·03	4·9	6·71
Superfine Weatings	0·148	0·745	0·060	0·895	0·01	5·4	8·90
Whey (dried)	0·114	0·838	0·921	0·829	1·71	4·1	10·00
Yeast (dried)*	0·378	0·688	0·214	2·183	0·03	13·7	8·21

Notes.—The digestible nutrients are calculated from poultry digestibility trials, except for foods marked *. The starch equivalent figures are calculated in the usual manner, and by the usual factors.

tion data are also included in order to facilitate the calculation of mashes balanced for egg production.

Method of Use of Tables.

Owing to the fact that fowls are kept in flocks, it is not possible to apply a feeding standard for egg production as rigidly as can be done in the case of cows for milk production. It is, however, possible to achieve economy in the use of feeding-stuffs by intelligent application of the data given in the above tables. A good method, capable of use under commercial conditions, is to give the daily maintenance requirement in the form of grain, and to allow either free access to a dry mash balanced for egg production, or, better still, to feed a wet mash, similarly balanced, varying the amount fed in accordance with egg production. The latter method is more economical than the former, since in the case of dry-mash feeding the amount of mash eaten is dependent on the birds' appetites and not necessarily on egg production, although it should be pointed out that a bird's appetite as a general rule increases with increase in egg production. If the amounts of grain required for maintenance starch equivalent are calculated from the maintenance requirements table it will be found that approximately 2¼ ounces of grain a day will be required by the light breeds and 2¾ ounces a day for the heavies. These amounts are higher than are normally fed in English practice, but it is interesting to note that the difference between the two amounts, i.e., half an ounce is the difference made in actual practice. This practice of allowing the maintenance requirement as grain, and then allowing the birds free access to a standard dry mash to provide for egg production is already in commercial use in Denmark. If, however, sufficient grain is given to provide for the energy requirements for maintenance more protein is provided than is necessary for maintenance. It will be found, by checking the theoretical requirements against the digestible protein and starch equivalent figures given in the table of composition of feeding-stuffs, that approximately 85 grams for light breeds, and 95 grams of grain for heavy breeds, allows for daily maintenance and approximately 36% egg production, both for protein and energy. This, in ounces, means 3 ounces a day for the light breeds, and 3⅓ ounces a day for heavy breeds.

The rest of the requirements for egg production is best given in the form of a wet mash balanced for egg production, as outlined below.

If, on the other hand, a dry mash and grain system of feeding is

preferred, the daily grain ration will be limited to 1½ ounces a day for light breeds and 2 ounces a day for heavy breeds, and mashes similar to those given later in the text (pages 307–9) should be used.

Calculation of a Mash Balanced for Egg Production.

Case 1.—*Balancing two foods for egg production.* For illustration, fish meal and coarse middlings are used, though normally a more complex food mixture will be used in constructing a balanced mash. The problem is to find how many pound of coarse middlings need to be added to 1 lb. of fish meal to provide a balanced egg production mash. Let this quantity of middlings be x lb.

Now Digestible protein eggs (Col. 6) = Starch equivalent eggs (Col. 7) when the mash is balanced for egg production. Therefore 1 × fish meal D.P. eggs + x × coarse middlings D.P. eggs = 1 × fish meal S.E. eggs + x × coarse middlings S.E. eggs.

Substituting the appropriate figures in Columns 6 and 7 (pages 78, 79), we get:

$$1 \times 17{\cdot}2 + x \times 5{\cdot}2 = 1 \times 6{\cdot}48 + x \times 6{\cdot}82$$
$$\text{That is } (6{\cdot}82 - 5{\cdot}2)x = 17{\cdot}2 - 6{\cdot}48$$
$$\text{whence } 1{\cdot}62x = 10{\cdot}72$$
$$x = 6{\cdot}6$$

The balanced egg mash will therefore be 1 lb. fish meal and 6·6 lb. coarse middlings, or in round numbers, 10 lb. fish meal and 66 lb. coarse middlings.

To find the number of eggs 1 lb. of this mixture will produce is also simple: it is done by taking the figures in either Column 6 or 7 of the table and multiplying by the pounds of each food used in the mixture.

Thus, in the example given, 76 lb. of the mixture contain 10 lb. fish meal and 66 lb. coarse middlings.

Substituting the appropriate figures in Column 6, we get $10 \times 17{\cdot}2 + 66 \times 5{\cdot}2 = 172 + 343{\cdot}2 = 515{\cdot}2$.

That is, one pound of the mash will provide for 6·8 two-ounce eggs approximately.

Case 2.—*Balancing more than two foods for egg production.* In this case the procedure is to mix all the energy-producing foods in any desired combination, to ascertain the D.P. egg value and the S.E. egg value per lb., and then to equate this against the protein food as shown in Case 1. In this case we will assume that the foods to be used are bran, coarse middlings, Sussex ground oats and meat meal, and that the bran, middlings, and Sussex ground oats are to be mixed in the proportions 2 bran, 2 middlings, 1 Sussex ground oats.

From Columns 6 and 7 we work out the D.P. and S.E. values as follows:

	D.P. Eggs.	S.E. Eggs.
2 Bran	9·2	8·86
2 Coarse middlings..	10·4	13·64
1 Sussex ground oats	3·3	7·03
5 lb of mixture equals	22·9	29·53
Therefore 1 lb. equals	4·6	5·91
1 lb. meat meal equals	23·2	10·35

We are required to mix x lb. of the cereal mixture with 1 lb. of the meat meal so that the D.P. eggs of 1 lb. of the final mixture equals the S.E. eggs per lb.

$$\begin{aligned} \text{That is, } 4{\cdot}6x + 23{\cdot}2 &= 5{\cdot}91x + 10{\cdot}35 \\ \text{whence } 1{\cdot}31x &= 12{\cdot}85 \\ x &= 9{\cdot}81 \text{ or } 10 \text{ (approximately)} \end{aligned}$$

The balanced mixture would thus be (all parts by weight):

4 Bran.
4 Coarse middlings.
2 Sussex ground oats.
1 Meat meal.

Applying the figures for D.P. eggs given in Column 6, we find that 11 lb. of this mixture would provide for $4 \times 4{\cdot}6 + 4 \times 5{\cdot}2 + 2 \times 3{\cdot}3 + 1 \times 23{\cdot}2 = 69{\cdot}0$ eggs. Therefore 1 lb. of the mixture would provide for 6.3 eggs approximately.

In applying this system of rationing in practice, taking light breeds as an example, 3 ounces per head per day of maize or maize and wheat would be given split into a morning and evening feed, and sufficient wet mash given mid-day to allow for 70% egg production. For a flock of 100 birds 18 lb 12 oz. of grain would be given, and approximately 5½ lb. of the mash mixture given in Case 2. For a similar sized flock of birds of the heavy breeds, the same amount of wet mash would be given, but the grain ration would be increased to 20 lb. 13 oz.

Feeding Standards for Sheep.

Mutton and fat lamb production, being essentially an outdoor occupation in which the bulk of the foods fed are standing crops, obviously does not lend itself to any precise form of rationing; nor

is it at all easy to obtain accurate and precise feeding standards. The main object of a feeding standard must therefore be to act as a guide in the formulation of the nature and amount of the concentrated ration to be added as a supplement to the main crops fed off the land. The standards which follow conform to lowland sheep farming conditions, and, as far as can be ascertained, agree with feeding practice.

STANDARD REQUIREMENTS FOR SHEEP, IN POUNDS*

Live Weight.	Appetite: Dry Matter per week.	Maintenance Requirement per week.		Production Requirements.	
		Starch Equivalent.	Protein Equivalent.	Prot. Equiv. per week.	S.E. per lb. L.W. increase.
20	5·3	1·9	0·08	0·7	1
40	9·5	3·0	0·16	1·0	1¼
60	13·3	4·0	0·24	1·2	1½
80	16·7	4·8	0·32	1·4	1½
100	19·7	5·6	0·38	1·4	2
120	22·6	6·3	0·46	1·3	2½
140	25·2	7·0	0·54	1·1	3
160	27·6	7·7	0·62	1·0	3¾
180	30·0	8·3	0·70	0·8	4
200	31·9	8·9	0·78	0·8	4

PRODUCTION REQUIREMENT PER LB. LIVE-WEIGHT INCREASE

Stores	2 lb. starch equivalent.
Half-fat	2·5 lb. starch equivalent.
Nearly fat	3·0 lb. starch equivalent
Fat	3·5 lb. starch equivalent.

EWES SUCKLING LAMBS. PRODUCTION REQUIREMENT PER GALLON OF MILK

4 lb. starch equivalent, including 1 lb. protein equivalent.

Method of Use of Standards.

Example.—Lambs, 109 lb. average live weight, folded on swedes and intended for slaughter. Expected average live-weight increase, 2½ lb. per week.

Requirements per Week.	Dry Matter.	Protein Equivalent.	S.E.
Maintenance	—	0·38	5·6
Production (2·5 lb. S.E. per lb. L.W.)	—	1·4	6·25
Total ..	19·7	1·78	11·85

* Some of the data contained in these tables are given in tables published in the Ministry of Agriculture's Bulletin No. 48, and are here reproduced by permission of the Controller, H.M. Stationery Office.

The lambs will be allowed approximately 15 lb. of swedes a day and hay *ad lib.* in addition to a fixed allowance of concentrate. The hay will amount to say, ⅓ lb per head per day.

Ration, per Week.	Dry Matter.	Protein Equivalent.	S.E.
100 lb. Swedes	11·5	0·7	7·3
2⅓ lb. Hay	2·0	0·1	0·86
3½ lb. Dried brewers' grains ..	3·1	0·44	1·69
3½ lb. Undecorticated cotton cake	3·0	0·54	1·40
Total ..	19·6	1·78	11·25

The requirements would therefore appear to be satisfied by allowing 1 lb. per head per day of a mixture of cotton cake and dried brewers' grains, equal parts, and ⅓ pound of average quality meadow hay.

Ewes Suckling Lambs.

Studies on the milk yields of ewes of various breeds have shown that the milk yield may vary from approximately 1½ gallons a week to 5 gallons among individuals, also that the milk itself shows considerable variations in its chemical composition. Precise rationing of suckling ewes is consequently impossible under farming practice. Based on the average chemical composition, and assuming that the ewe is as economical a converter as the dairy cow, it would appear that the food requirements per gallon of ewe's milk are 4 lb. S.E. and 1 lb. protein equivalent. If this is the case, the production mixtures suitable for dairy cows would be equally suitable for ewes, with the proviso that the quantity to be fed per gallon of milk expected is 1·6 times that required per gallon of cow's milk. Since the approximate quantity of a balanced milk mixture required per gallon of cow's milk is 4 lb., 1 lb. of such a mixture per ewe per day would be sufficient for just over 1 gallon of milk per week, 1½ lbs. per head per day would suffice for nearly 1¾ gallons a week. The requirements of ewes folded on roots or green crops, and receiving in addition up to ½ lb. of seeds, meadow clover or sainfoin hay when available will be satisfied for adequate milk production by the addition of 1 to 1½ lb. per day of concentrates balanced for milk production.

SECTION B. PRACTICAL CONSIDERATIONS

CHAPTER V

THE COMMON FEEDING-STUFFS OF THE BRITISH ISLES

IN order to understand the theory and the practice of rationing farm animals it is essential to know details concerning the main feeding-stuffs available. The chief chemical features of the foods may be found in Appendix I, and only the chief practical characteristics will be given here. Since the feeding-stuffs available must vary from one country to another, it is proposed to describe only those found commonly in this country, for it is impossible to include the feeding-stuffs of the farm animals of the world within the limits of this book.

For convenience this chapter will be divided into sections dealing with concentrates, succulents and roughages, but grassland and its various products will be described in a separate chapter.

Concentrated Foods.

The concentrated foods are those which contain a relatively high proportion of nutrients per unit of weight; usually such foods are dry, i.e. at most only one-sixth of their weight is water; they are used primarily in production rations for fattening, for milk production, for growth and for work; they are costly per ton and must be fed sparingly to the proper animals in the correct ratios and quantities.

Wheat. *

The aim of farmers is to grow wheat of such good quality that it will sell well for seed, for flour, for bread making or for biscuits, but usually a certain amount of inferior grain is produced which can be given only to stock. On some farms all the wheat grown is only suitable for feeding to stock; whilst on others, when the price of concentrates is high millable wheat will be fed to stock. Wheat can be given to all farm animals but it is not a "safe" food because if fed indiscriminately it may easily produce serious digestive disturbances, possibly on account of its low fibre and high gluten content. In general, wheat should not exceed 25% of the total ration of concentrates being fed; provided this rule is observed wheat may replace

* Owing to wartime regulations farmers can only retain for feeding to livestock up to 5 per cent of wheat tailings unless the grain is certified as non-millable wheat.

part of the cereals in the rations of all stock. The form in which the grain is given will depend on the class of stock (see Chapter VII). Several by-products of wheat are produced by the milling industry but space only permits of the discussion of two of the more important of these products.

Bran.—When wheat is milled into flour the large pieces of skin of the grain are separated from the flour, and this is what is called bran. Two kinds of bran are on the market, the ordinary and the broad bran; although the latter has the slightly higher food value, on analysis, and commands a slightly higher price, experiments have failed to detect any differences when the two kinds have been fed to farm animals. Bran is so much in demand by livestock feeders that it usually sells at a price higher than its mere analysis warrants, this is because the bran has medicinal properties, it is laxative when fed as a mash. Bran mash is exceedingly useful on the farm, for feeding to females either just before and, or, just after, young have been born, as a mild laxative: at such times medicines are often too severe and produce unnecessary suffering. Bran, in addition to its medicinal value, is reputed, when fed in a dry form, to stimulate milk production in all lactating animals; it is not, however, a very concentrated food as evidenced by the fact that 6 lb.* are necessary to produce 1 gallon of cow's milk whereas only 3½ lb. of some foods, and of many mixtures, are required to produce the same quantity of milk. Bran is often used freely in the rations of fattening sheep and cattle, but, since carbohydrates are the nutrients primarily required for such purposes, the use of appreciable quantities of bran must increase the cost of the rations. Bran is a very "safe" food for working horses but as proteins are the chief nutrients required for work usually other foods are cheaper. Apart from the medicinal value of bran for farrowing sows and gilts it is a food which is too bulky for the relatively small digestive tract of the pig. For poultry, bran is too bulky a food to be fed in appreciable quantities, but owing to its dietetic value, it is often included in chick and poultry mashes in quantities up to 25% of the ration.

Weatings or Middlings.—A further by-product from the milling of wheat is weatings which consists of smaller pieces of skin than are found in the bran, together with a certain amount of the larger fractions of flour. Weatings, formerly known as middlings, sharps, thirds, pollards and several other local names associated with the fineness of the product and the locality in which they have been produced, have a very different composition from the bran which has

* This is 5 lb. if the latest standards are used.

a ratio of starch to protein of 4:1, whereas weatings is 6:1. Two kinds of weatings are produced from home-milled flour, namely weatings which do not contain more than 5·75% of fibre and superfine weatings which are guaranteed to contain less than 4·5% of fibre, but for convenience, these two forms will be referred to merely as weatings. Normally weatings are used primarily in the rations of pigs and poultry, in these cases it, not infrequently, is the most abundant ingredient in the ration. Weatings are so palatable that they are frequently given to piglings, calves and chickens, then this food is, in general, soaked prior to feeding because it is likely to be pasty in the mouth, and in the stomach, if fed dry.

Barley. *

Barley contains a higher ratio of starch to protein than is found in any other cereal grown in this country and in consequence it is particularly suitable for feeding to fattening stock; in this country barley frequently forms the basis of the ration of fattening pigs, a ration for such pigs may contain as much as 70% of barley. In some districts barley is fed freely to both fattening cattle and to sheep; it may also provide some of the carbohydrate portion of the ration of dairy cows. Some practical men refuse to give dairy cows any barley, but experience shows that it may be used quite advantageously in a mixture for such animals. When oats are relatively more expensive than barley the latter may replace 33% of the oats in the rations of both working and of growing horses. If excessive amounts of barley are given to poultry trouble results; for this reason the use of barley in poultry rations is unpopular. It has been proved, however, that barley, either as grain or meal, can with advantage be used in poultry rations up to a level of 20–25% in either the mash or the grain ration.

Malt Culms. When malt is manufactured from barley the latter is sprouted for several days before this process is suddenly terminated, at which time the sprouts are often about an inch long; the sprouts are then separated from the barley residue and dried and put on the market as malt culms. The poorer qualities of culms are sold as organic manures and only the better qualities are used for feeding to live stock; with this state of affairs the quality of the culms is likely to be very variable, and, if at any time they are bought for feeding, care must be taken to ensure that a good quality has been purchased. This feeding-stuff is really a protein concentrate and is commonly found in the balanced cubes sold by various firms for feeding to dairy cows; where farmers habitually make their own mixtures for

* Owing to wartime regulations farmers can only retain for feeding to livestock 5 per cent of the total weight of barley threshed unless the barley is certified as unsuitable for malting, brewing, distilling, or the manufacture of human food.

dairy cows the malt culms may be included in such small quantities as 10 to 15% of the concentrated ration. The chief value of this by-product, in a dairy cow's ration, is to reduce the risk of pastiness in the mouth and, to use an American term, lies in "lightening" the ration and so making it more palatable. A warning should be given that this dry food is inclined to swell appreciably after consumption and, for safety, should never be given in quantities greater than 4 lb. to cows, and 6 lb. to heavy horses, per day.

Brewers' Grains. In the process of manufacturing beer most of the starch of the grain is converted into alcohol and the husk or skin of the grain is left as residue. These skins of barley grains are known as brewers' grains and are wet at the end of the brewing process; they are sold, in this condition, to farmers in the vicinity of the brewery, but as it is often impossible to dispose of them all locally it is usually necessary to dry them and they are then known as dried brewers' grains. The wet grains may be stored in the wet form in pits, with or without the addition of salt to act as a preservative, but unless air is completely excluded, and this is difficult to achieve, the grains rapidly become sour and mouldy. The wet grains are very palatable and are often fed to dairy cows in such large quantities as 40 lb. per head per day, because they are reputed to stimulate milk production; since they do not stimulate butter-fat production it is well known that high feeding with brewers' grains leads to the production of big yields of poor-quality milk. The wet grains also have the reputation, when fed liberally, of over-stimulating milk production and so reducing the vitality, or constitution, of the cow. Wet grains may be given to fattening cattle as a succulent food, analysis showing them to be slightly more concentrated food than the ordinary roots, for, whereas roots contain 85 to 90% water, brewers' grains contain only 75%.

Dried brewers' grains have a starch to protein ratio of 4:1 (i.e. balanced for milk production), but they are more concentrated than is bran; they also have the same stimulating effect on milk production as the wet form and in consequence are frequently fed with this object to both cows and ewes, as part of the concentrated ration. The dried grains may be given to horses, cattle and sheep as 30 to 40% of the total concentrates, but the food is too fibrous, or bulky, for feeding to pigs of any age.

Distillers' Grains. Barley, maize, rye, rice, molasses and potatoes are mixed together in varying proportions in the distilling of gin and whisky; after the requisite liquid has been extracted, the residue, mainly the skins of the cereals concerned, is known as distillers'

grains. This residue is used in precisely the same way, both wet and dry, to the same class of animals as brewers' grains, but it should be remembered that the distillers' grains are slightly more concentrated, in both carbohydrates and proteins, than the brewers' grains. Experience also shows distillers' grains to be the more unpalatable kind.

Yeast. When beer is manufactured yeast is filtered from the liquid and it may be dried for stock feeding, for which purpose it is valuable for it often contains over 40% of proteins. Provided the drying has been carefully carried out the yeast may be rich in vitamins B and B_2. Much of the dried yeast of this country is used sparingly (up to 10%) in the concentrated mixtures for poultry and for pigs; to a lesser extent it is given to dairy cows.

Oats.

Analyses show oats to be the poorest cereal* used for feeding in this country, yet they have a wonderful reputation as food for cattle, horses and sheep. It will be observed that pigs have been omitted purposely from the list, for oats are usually considered to be too fibrous for pig feeding, since they contain approximately five times as much fibre as is found in wheat, rye, rice or maize. When oats are specially finely ground, they are then called Sussex ground oats; in this form they may be fed, in limited quantities, to pigs with apparent safety, for the pig can digest the oat husks when they are finely ground. Oats often form 33 to 50% of the grain ration of laying hens during the summer months, and laying and chick mashes generally contain 10 to 20% of Sussex ground oats. For the production of Surrey fowls a mixture of skim milk and Sussex ground oats is generally used and yields excellent results.

Oats are so safe for feeding to cattle, horses and sheep, presumably because of their high fibre content, that they may be given in large quantities, e.g. up to 16 lb. per head per day to cattle in the final stages of fattening, and certainly up to 14 lb. per head per day to heavy horses when they are working hard. In fact, in this country, oats normally form the basis of the concentrated food for working horses. There is no better carbohydrate for feeding to young stock, e.g. to calves, to foals and to lambs, than oats; the first concentrate mixture ever given to such animals usually contains some oats.

Although there are various oat products on the market they are available in such small quantities that they are relatively unim-

* In carbohydrates.

portant and in consequence will not be discussed here. This brief outline of the uses of oats would not be complete if no mention were made of sprouted oats. From time to time various authorities have claimed that the feeding of small quantities of freshly sprouted oats to sterile stock, especially heifers, will, provided they have no physical defects, make them breed, but investigation into this problem suggests that the benefits anticipated are rarely obtained. It is also doubtful whether the feeding of any sprouted cereals will have any beneficial effect on non-breeding females.

Rye. *

On the very poor light soils of this country, especially arid ones in the eastern counties, rye is the only cereal that will grow and produce a satisfactory yield: usually rye has little sale value except as such and the only means of cashing it is through the medium of livestock. Rye can be fed to various of the farm animals, but it must always be remembered that a disease very commonly found on ears of rye is ergot and it contains a poison which, if fed to pregnant stock, may induce abortion. Most cereals cause digestive disorders when fed within a few months after harvesting, but of all the cereals rye is the most likely to produce these disorders. In view of the risks associated with using the grain, and because it is rather unpalatable, it is usually given in small quantities, 15 to 20% of the rations, to replace other cereals for horses, cattle, sheep and pigs that are growing and fattening but are not pregnant.

Maize.

Throughout the world no cereal is more widely fed to livestock than is maize. It contains a higher percentage of carbohydrates than any other cereal, and as it is exceedingly palatable it plays a big part in fattening livestock. In some countries, where the maize grain is grown, maize is given in such large quantities to fattening stock, especially pigs, that the texture of the fat in the meat carcases produced is soft, oily and often rather unpalatable. In this country maize is usually fed with more discretion, and rarely in excess, but, whenever it is much cheaper than home-grown cereals, there is always the danger that it will be given too freely to farm animals. Although maize is pre-eminently a fattening food it may be given in one form or another to all kinds of farm animals, provided it is mixed with the other appropriate foods. Yellow maize is also valued on account of its vitamin A content. White maize varieties contain,

* Owing to wartime regulations farmers can only retain for feeding to livestock 5 per cent of the rye threshed unless the rye is certified as unsuitable for milling.

however, little or no vitamin A, but are suitable for inclusion in fattening mixtures.

Flaked Maize. Several firms have placed on the market maize that has been cooked and flaked by passing the steam-cooked grain between hot rollers; this process is supposed to take nothing from the grain, except possibly a little oil, and to increase its palatability and its digestibility. The resulting flaked maize is the food which, of normal food-stuffs, is the richest in carbohydrates that can be obtained for stock feeding. Naturally the price of this processed maize is slightly higher than that of the original grain, but progressive feeders consider the price is not excessive and they include this food in their mixtures for the following stock—dairy cows, especially higher producers, fattening cattle, especially baby beef, fattening lambs, foals and yearling horses, suckling pigs just before they are weaned and fattening pigs. It will be observed that the above list includes, mainly, the young farm animals for this food is very palatable and it is easily digested.

Whenever the price permits flaked maize may be given freely to all classes of farm animals in large proportions of the rations, e.g. for low-yielding cows and for baby beef cattle it may constitute 66% of the concentrates though such a high proportion is not advised. It should be remembered that when flaked maize is used to replace oats, whereas the starch equivalent of oats is 60% that of flaked maize is 84% and, in consequence, replacement should never be on pound for pound basis.

Maize Germ Meal or Cake. When corn flour is obtained from maize the original grain is cleaned, washed in weak sulphuric acid solution to facilitate the removal of the husk and germ; the grain is crushed and then deposited into tanks of water where the germ, owing to its high oil content, floats and is easily collected from the surface. The germ is then crushed to extract the oil and the residual cake is either sold as such or ground to a meal before selling. The germ meal has an analysis very similar to flaked maize except that its starch to protein ratio is 8:1 instead of 9:1. The germ meal is usually very palatable and may be used to replace cereals in rations of all growing, fattening, working and lactating animals, actually most of the germ meal used in this country goes to dairy cows.

Maize Gluten Feed. After the germ has been removed from the maize grain as mentioned above, the residue is crushed and ground, most of the starch being removed and manufactured into corn flour. The residuum of skin, or bran, and the gluten of the grain is then

dried and ground either both fractions together or separately. When the latter is the case the gluten feed is produced. It seems that the exact details of procedure in the various factories, where gluten feed is produced, differ from factory to factory, and, in consequence, the resulting by-product is likely to be of rather varying composition. This gluten feed has a ratio of starch to protein of about 4 : 1 and is therefore of itself balanced for milk production for dairy cows; it would be a great mistake to feed the food as the sole concentrate as it is well known that all maize products are deficient in some of the amino-acids that are essential for life. The gluten feed is most widely used as part of the rations of lactating cows and ewes. Experience is varied regarding the palatability of the food-stuff, but, in general, it is not as palatable as the original grain or the residues produced when flour is obtained from wheat. In view of this frequent unpalatability and the usual low essential amino-acid content the gluten feed should be used sparingly and should not exceed 25% of a concentrated ration.

Buckwheat.

Although this food is not a true wheat its analysis makes it similar in food value to oats. Buckwheat is, however, quite different from all the cereals, namely, that although it is a carbohydrate concentrate it has a very high fibre content. Consequently care must be exercised whenever this food is given to pigs and poultry.

Acorns.

Contrary to expectations acorns are a carbohydrate food. For many years acorns have been eaten by pigs, because in the wild state they foraged around in forests and under trees. In recent times acorn feeding has been neglected, but when food supplies have been short, acorns have been collected and fed to stock. Acorns may be fed to pigs, sheep, and goats as gathered, or they may be dried and ground into a meal and incorporated into a mixture for pigs. It is not wise to feed acorns to pregnant sows, to dairy cows, to beef cattle, or to any cattle, because of the risk of acorn poisoning. In the autumn it may be necessary to keep cattle off pastures if acorns are abundant.

Horse Chestnuts.

Horse chestnuts are another carbohydrate food, but they may be a little bitter and in consequence they may be unpalatable. They must be fed with succulent foods, since they are inclined to produce stoppages. Sometimes salt is given with the chestnuts to increase their palatability. If stored when damp the nuts go mouldy very

readily and when in this condition they are unsafe to use for feeding to any stock. The horse chestnuts can be dried and ground into a meal. Whether fed fresh or dried they can be used sparingly in rations for cattle and pigs.

Rice Meal (Rice Bran, or Pollard).

The whole grain is rarely, if ever, used by itself in this country for stock feeding, but considerable quantities of rice meal are often available. As harvested and cleaned for the miller, rice grains are brownish or reddish and enclosed in a hard grey flinty husk. After dehusking the brown rice grains are treated with a machine called the "huller" which removes the outside seed coat or bran. Rice meal is made by grinding this bran or coat of the rice, and also a certain proportion of small whole rice grains. It is obvious that the composition of the meal, especially with reference to its oil content, will depend on the proportion of small rice grains added; since a high oil content is disadvantageous, great care must be exercised when purchasing the meal. This product is a carbohydrate food similar in chemical composition to barley though not as safe for feeding as the latter; it is inclined to be unpalatable, and a high oil content may make it laxative. It is most commonly used in the rations of fattening cattle, of pigs and of dairy cows, but it is rarely used in the rations of any young stock owing to its variable composition.

Tapioca Flour (Manioc Meal).

Whenever the prices of feeding-stuffs are high new products are imported from abroad and of these feeding-stuffs tapioca flour is a fairly recent addition. It is essentially a food very high in carbohydrates and exceedingly low in proteins. It is used primarily in the rations of fattening pigs after they have reached 100 lb. live weight, when it may represent up to 25% of the total concentrates being given.

Sago Pith Meal.

This is another of the carbohydrate concentrates that are periodically imported into this country. The meal contains as high a percentage of fibre as is found in barley, but less protein, and more carbohydrates than the normal cereals used in this country. This food may also be used in the rations of fattening pigs in the same way as tapioca flour.

Dari.

Both sorghum and maize are grown in the sub-tropical countries and it is the white form of the sorghum that is known in this country as dari. This grain is very similar in composition to barley but it contains even less fibre than is found in the latter, for this reason dari is particularly suitable for feeding to poultry (in fact the bulk of the dari used in this country is used in poultry rations) but a small proportion is also incorporated into proprietary rations for dairy cows.

Locust Bean Meal.

When one hears the name of a "bean" one naturally thinks of high protein foods but in the case of the locust bean this is incorrect, for it usually contains only 4% of protein equivalent to 71% of starch equivalent. This high carbohydrate concentrate frequently contains so much sugar that crystals may be visible to the naked eye. Locust bean meal is, therefore, exceedingly palatable and is fed to fattening cattle and especially to lambs that are folded on roots; this practice has an added value for this meal is rather constipating and frequently corrects any tendency, there may be, of the lambs scouring on roots, or on succulent grass.

Sugar Beet Pulp or Slices.

In order to extract the sugar from the sugar beet the latter is sliced and heated in a plentiful supply of water to dissolve out the sugar. After the optimum quantity of sugar has been extracted from these slices they are a waste residue (pulp), which is sold to the farmer for stock feeding both in the wet and in the dried form. Wet beet pulp, like brewers' grains, does not keep and can be used only for feeding on farms near the factories; hence the majority of the pulp produced is dried. The dried pulp is sold in two forms, both with or without molasses, which is a black treacle that will be described later. The molasses are added largely because the sugar beet factories find difficulty in disposing of this liquid, but actually its addition increases the palatability of the pulp. It seems that the molassed pulp has occasionally produced a fishy taint in cows' milk, due to the presence of betaine in the pulp, when large rations of pulp have been fed, but this is very rare. The dried pulp is a carbohydrate concentrate which has been demonstrated, by experimental work, to be similar in food value to oats; the pulp, however, contains a very high proportion of fibre which renders the food even less suit-

able for pigs even than oats. Experimental work has shown that small quantities of the dried pulp will replace cereals in the rations of the older pigs but that the pulp should not be fed when quick live-weight gains are required. The dried pulp is not very palatable when first offered to stock but once they have acquired the taste for it they will eat it readily; even when fed in large quantities it seems to have no effect on the bowels. It may be used either as a carbohydrate concentrate or to replace roots (1 lb. pulp=7 to 10 lb. of roots depending on the kind and quality). Whenever appreciable quantities are given to stock the pulp should be soaked prior to feeding in 50% of its own weight of water; if the dry pulp is given to stock they should have access to water. The pulp may be given to fattening cattle (up to a maximum of 16 lb. per head per day) to dairy cows as concentrates or as a succulent (4 to 6 lb. replacing 40 lb. roots), to store cattle, to both breeding and fattening sheep and also to working horses. The dried pulp is usually an exceedingly cheap food but frequently farmers do not appreciate its value. If stored in a dry place, it will keep from one season to another and can be used as an insurance against summer drought. Unquestionably this by-product will play an important part in the feeding of stock in this country for as long as the sugar-beet industry continues.

Molasses or Treacle.

Whether sugar beet or sugar cane are used for the manufacture of sugar a dark brown liquid is produced which is known as molasses or treacle. This liquid is very palatable for it contains a very high percentage of sugar. Although all animals seem to like sugar it is wasteful to feed it to ruminating animals for the bacteria which are essential in rumination produce so much gas from the sugar that the animal gains very little nutrient itself. Sugary foods, and especially treacle, are used to increase the palatability of a ration; in some cases the object is to induce stock to eat poor-quality foods but in others it is to assist high-producing animals to consume larger quantities of concentrates. Manufacturers of balanced concentrated foods frequently use molasses to assist the palatability, and to bind together the foods used in manufacturing cubes for all kinds of livestock. It is very questionable whether it is worth while for an ordinary farmer to purchase molasses for stock feeding unless it is to entice stock to eat poor-quality hay and straw at times when roughages are expensive. In the future molasses may be much in demand for making molassed silage, for which purpose molasses from the sugar cane or from the sugar beet may be used.

The Protein Rich Concentrates.

Most of these concentrates are the residues from the manufacture of other products. It is proposed to discuss the products from the oil industry last and to take the other products and by-products first.

Horse Beans or "Beans."

Of all the concentrated foods grown in this country beans is the one grown solely for live stock, and the best and safest natural food which contains a high proportion of proteins. The proteins found in beans are particularly valuable for stock because they contain so many of the essential amino-acids; this, no doubt, very largely accounts for the stimulating action they have on milk production when fed to dairy cows. Beans may be fed to all farm animals young and old, growing, working, milking and breeding, and are given in various forms to various animals (see general principles on the preparation of foods p. 137). It should be pointed out that new season's beans are often difficult to grind for feeding because they become pasty on the rollers. New season's beans may be identified by the fact that they are usually plump with greenish, yellow or light brown skins, whereas old season's beans have dark brown or black, sometimes even blue, skins. Bean meal, especially if moist beans are ground, is very likely to heat on storage; heated bean meal is very unpalatable and is liable to cause scouring when fed to farm animals. The risks of heating are reduced by grinding old beans, by using them within a week of grinding, and, if they have to be stored, by leaving plenty of room for the circulation of air around the sacks of meal.

Peas.

Various kinds of peas are grown in this country, the field peas, maple peas and dun peas; these are commonly used for feeding to stock as also are peas which are grown for human consumption and which are in excess of requirements. Peas have much the same analysis as beans except that they contain a slightly lower proportion of protein to starch. They are fed to the same kinds of stock and in approximately the same quantities as beans, but peas are particularly popular with shepherds and relatively more are fed to sheep than to the other farm animals.

Lupins.

The opinion is quite commonly expressed that the lupin seeds are poisonous owing to the presence of lupinotoxin and consequently are not safe for feeding to any stock ; in other words the seed should be grown solely to provide a supply of seed to grow the crop for green manuring. Carefully made enquiries show, however, that some farmers have given lupins to arable land sheep and no harm has ensued, provided only small quantities are given at a time, and lupins are introduced into the ration gradually. In this way up to 20% of the concentrated foods has been lupins.

No one seems to have had much experience of feeding lupins to stock other than sheep. The above refers to the ordinary blue field lupins, but the yellow lupin, also known as the sweet lupin, is now being grown in this country, and it is reported that on the Continent (Europe) this yellow lupin is not poisonous for stock.

Fish Meal.

Fish meal is made from residues from the fish industry; the better quality is sold for stock feeding but the poorer is used as an organic manure. Of the two main kinds sold for stock consumption the better is the "white" meal which consists of bones, heads and flesh of fish, containing a low percentage of oil, e.g. haddock, plaice, halibut, etc. The poorer meal is that which is obtained from mackerel and herrings which contains a relatively high percentage of oil (10 to 15%); this oil is likely to produce a fishy taste in the produce of stock receiving the meal. On the other hand the good-quality white fish meal containing a low percentage of oil is very unlikely to produce any taint. The special value of good-quality white fish meal lies in the fact that it contains a very high percentage of minerals—particularly lime and phosphorus that are so essential for bone production in livestock; also the proteins and minerals of fish meal are easily digested because of their animate origin. Without a doubt stock farmers cannot obtain a food better in essential minerals than is fish meal. In addition fish meal contains a very high percentage of proteins and also may contain vitamins A, D and G. For all of these reasons this food is particularly suitable for rapidly growing young stock, primarily pigs, poultry and to a lesser extent to calves and foals. Owing to its richness and also to its cost and also to the risk of producing taint usually not more than 10% of any ration is fish meal. When pigs receive 10% of fish meal in a ration it is unnecessary to add any further minerals, except in special cases where iron is needed. A small amount of good-quality fish meal is often put, with advantage, into the rations of high-yielding dairy cows.

The poor-quality fish meal, and herring meal, both of which may contain a high percentage of oil and evoke taints in produce if fed to dairy cows, fattening pigs and to poultry, may, however, be used as protein feeds if given to the right animals. Store cattle and beef breeding-stock when housed in winter often receive large quantities of straw and little or no hay; such stock will be receiving too little protein unless a high protein cake or meal is given. Herring meal or low-grade fish meals may be safely and economically fed in such cases. These poorer fish meals may be fed to young heavy horses, possibly to pregnant and to suckling sows, and also to calves being reared for the dairy herd.

Meat Meal.

Various scraps of meat from large slaughter houses and abattoirs are dried and ground into a meal. It is obvious that the quality of such meals, made in different ways and at various factories, will contain varying amounts of actual meat and, in consequence, the percentages of proteins present will vary. Meat meals have very varying compositions, reaching a maximum of 65% of proteins but more commonly containing only 40%. The meat meals are particularly valuable to livestock because the proteins they contain are of animal origin, consequently are easily digested by stock. Meat meals are given to supply proteins in the rations of pigs and poultry, but it should be remembered that unlike fish meals they contain very little minerals and when fed mineral supplements are usually necessary. According to the methods of processing used in manufacture, meat meals are grouped into two classes, high fat containing meals or low fat containing meals. Occasionally bad effects on the growth of animals have been noted where fatty meat meals have been used, and this has been proved to occur only when the fats have become oxidized or rancid, the free fatty acids produced exerting a deleterious effect on the vitamin content of the fat of the ration. This oxidation can be prevented if the meal is subjected to sufficient heat treatment during manufacture.

Meat and Bone Meals.

These are also residues from slaughter-houses but differ from the meat meals mentioned above in that bone residues are included. The addition of the bones has two effects on the meat meals; it dilutes them and so reduces the percentage of proteins, and in addition provides minerals which are essential for stock growth. These meals are mostly used for feeding to pigs and poultry; two

important advantages of using them are that the protein is of animal origin and that there is no risk of producing a taint in the produce.

Blood Meal.

A further product from large slaughter-houses is dried blood. Good samples of this meal will contain over 65% of protein and it is a very valuable protein suppliment for young stock, especially pigs and poultry, but, as with meat meal, minerals must be added if the aim is to replace fish meal entirely. Blood meal is of very varying quality, the poorest classes being used for manures; care must be exercised, therefore, in buying the meal.

Bone Flour.

The full name of the residue that is used for stock feeding is sterilized steamed bone flour, which, of course, consists of minerals and is made from bones after they have been heated to kill possible disease germs, and after extraction of gelatin fats and oils. It may be considered out of place to discuss this food here, but it is a product of slaughter-houses, some of which have just been discussed above. The best qualities of this flour may be fed with safety to stock but the poorer qualities are used as phosphatic manures. The sterilized flour is used for dairy cows as 2% of the home-made mixture, and may be fed to all milking and dry stock; the possible advantages, especially with high-yielding families, of using the flour are that it may reduce breeding troubles and the incidence of milk fever. When it is considered necessary to give the flour to livestock receiving no concentrates, i.e. when at grass, or when the stock dislike the flour in concentrates, it is possible to procure salt licks containing sterilized steamed bone flour and stock will often consume it in that form. Bone flour is often given in the mixtures for poultry and pigs, when fish meal is not given, and especially when the high protein supplement is meat meal.

Dried Skimmed, or Separated, Milk.

Cream is removed from milk, commercially, by means of a separator and the residual milk is known as separated milk. Formerly the milk was placed into pans for the cream to rise and the cream was skimmed off the surface by means of a hand scoop, then the remaining milk was called skimmed milk; this hand skimming left a certain amount of cream behind so that skimmed milk was usually

slightly richer than the separated milk. At factories the separator is used and there the milk is dried to improve the keeping qualities and to facilitate transport. The dried milk is used in various human foods; for stock it is exceedingly palatable, and is a rich food containing over 30% of protein equivalent and nearly 80% of starch equivalent, these nutrients being easily digested. This ease of digestion marks out the food as being particularly suitable for young stock especially when it is remembered that milk also contains, with the exception of iron, all the mineral substances required for growth and bone formation. The dried milk is too expensive to feed to the majority of farm animals—it is occasionally used in calf meals and gruels and for ailing young stock, but its main use is in mixtures for young poultry, for which it sometimes provides 5 to 10% of the ration. When calves are over 3 weeks old it is possible to rear them on skimmed or separated milk and hay and concentrates or on the dried separated milk remoistened, in which case 1 lb. of this milk powder and 9 lb. of water will give approximately 1 gallon of reconstituted skimmed milk. This will usually reduce rearing costs; especially in the winter when liquid milk is commanding a high price.

Dried Buttermilk.

In countries where large quantities of butter are made in factories one of the subsidiary processes is to dry the buttermilk. This product has an analysis very similar in all respects to the dried separated milk except that it contains less sugar than the latter and slightly more protein. It also has the same uses as separated milk, namely for human food, for young stock and especially for poultry rearing, but the authors have never heard of it being moistened to replace whole milk in calf rearing.

Dried Cheese Whey.

When cheese is made in factories it may be worth while drying the whey for stock feeding. The dried product contains about 9% of milk minerals, 12% of protein and approximately 70% of lactose, or milk sugar. The protein, consisting as it does largely of lactalbumin is of high biological value. The mineral content of the dried whey is similar to that of the dried separated milk as regards lime, but it contains only two thirds the phosphorus found in the dried separated milk. The dried whey is richer in vitamin B_2 than dried milk powder; partly for this reason and partly because the high lactose content is valuable in checking coccidiosis this food is very

popular for poultry feeding; this product is also used for young pigs and calves.

Residues from the Oil Industry.

In commerce a number of different kinds of oils are obtained from the various products of trees and plants, the residues being sold as meals or cakes for stock feeding. Originally these oils were obtained by crushing and then the residue often contained 8% of oil, but with recent advances these oils are now frequently extracted by solvents; the use of the solvent is more efficient in extracting the oil, and the residue from the process often contains only 1 to 2% of oil. When cakes and meals are sold the method of extraction is stated or otherwise; when no designation is given it is assumed that it is not an extracted form. Another method of extracting the oil is known as the expeller process, this develops friction and partially cooks the residue; with this process usually about 3% of oil is left in the residue. Cakes or meals containing oil in excess of 8% may cause digestive disturbances; 8% or under may be advantageous because it may make the cake laxative and there is some evidence that some oils, when fed to dairy cows, may increase butterfat production. For pigs the extracted meals are better than the ordinary meals because extra oil is of no advantage to the pig. It follows that when such cakes, or meals, are purchased attention must be paid to the oil content of the residue.

Some of the residues from the oil industry contain high percentages of fibre; if this is removed the residue is known as decorticated, if it has not been removed it is styled undecorticated. The removal of fibre increases the nutritive value of the food and such foods command high prices. When the fibre is left in the cake (the undecorticated form), it usually has a constipating effect on the animal eating it and the food may be used to counteract the laxative effects of other feeding-stuffs.

Linseed Cake.

Linseed itself is rarely used for stock feeding except, perhaps to sick animals, in which case the seed is either crushed, ground, soaked for a long period, or cooked, because the outer coat is very hard and indigestible. Because of its high oil content, when ground, it must be mixed with an absorbent food such as whole maize. Linseed cake is the most popular of all cakes on sale in this country, partly because it has been available for many years and its merits

are well known to farmers, but also because it definitely improves the general appearance of the stock receiving it; this is because it is slightly laxative and the tone of the animal is improved, the coat assuming a healthy appearance or bloom, and the skin becoming pliable. Linseed cake is very palatable and is widely used as the main concentrate for ailing and young calves, lambs and foals, and also stock being prepared for the live classes at shows. Actually the nutritive value of linseed cake in terms of starch equivalent is 74% and of protein equivalent 25%; the latter falls far below several other less popular cakes. On the other hand the price is always high per ton, and especially when the cost per unit of protein equivalent is considered. Thus on account of cost linseed cake can only be used very sparingly, if at all, for dairy cows, young calves, suckling ewes, fattening cattle and fattening sheep. Without a doubt many farmers still use this expensive cake far too freely, much to their cost.

Both linseed cake and linseed meal contain linamarin from which prussic acid may be derived by enzyme action; the acid is a deadly poison to calves and great care must be taken in preparing linseed, both cake and meal, for calf feeding. In this country the linseed cake meal is rarely purchased, but in some countries the meal is used in preference to the cake.

Ground-nut Cake.

This cake is made from ground-nut or, as it is sometimes called, earthnut. The decorticated form of this cake contains 41% of protein equivalent and 73% of starch equivalent which marks it out as the richest cake normally available, the undecorticated form contains only 27% protein equivalent and 57% starch equivalent. The decorticated cake is very palatable and may be fed with safety in whatever quantities are necessary to balance a ration to cattle of all kinds and ages over 3 months, to sheep over 2 months of age and very occasionally to horses. Usually the price per ton is so low that it is a far cheaper food than linseed cake. The undecorticated cake is given chiefly to store cattle and low-producing dairy cows, but very little to any other animals.

Cotton Cakes.

The residues from the extracts of cotton and oil often assume the name of the country of origin, e.g. Bombay and Egyptian; these two kinds of the cotton products (cakes) are undecorticated, in fact, whenever nothing is specifically stated regarding the decortication it is the undecorticated form that is implied. The undecorti-

cated cotton cake usually contains about 40% of starch equivalent and some 15% of protein equivalent. The main value of this cake lies in the fact that it is constipating on account of its high fibre content; in consequence the cake is frequently fed to cattle, but less frequently to sheep, to counteract the laxative effect of young luxuriantly growing grass or of heavy root rations. The cake is not very palatable and often difficulty is experienced in persuading cattle, on young grass in spring, to eat the cake; sometimes they have to be housed for a short time daily before they will eat it.

When the fibre is removed two forms are produced, the decorticated cotton cake, and cotton-seed meal (sometimes referred to as C.S.M.); these foods contain about 70% of starch equivalent and 35% of protein equivalent and are therefore high in proteins. They are not exceedingly palatable, but cattle and sheep will eat them in a concentrated mixed ration. It is very doubtful whether either the undecorticated or the decorticated cotton cake should be fed to sheep under 4 months of age, or to calves under 6 months because the products are difficult to digest. In some foreign countries, where the cake is produced, it is fed in very large quantities to stock and frequently gossypol poisoning occurs; this poisoning is more common in pigs of all ages, in young sheep and in young cattle than with older cattle and sheep. Whenever the cotton has been cooked in the oil-extraction process there is less risk of poisoning.

Undecorticated cake may be distinguished from the decorticated by the fact that the former contains quantities of cotton wool large enough to be visible and of black hulls, and is greenish brown whereas the decorticated cake or meal contains little cotton wool and hulls, and is decidedly yellow in colour. The inclusion of cotton-seed meal in poultry rations is not considered desirable, since eggs produced by hens fed with this meal have been shown to develop "pink whites" in storage.

Soya-Bean Cake and Meal.

No food has become popular in this country more rapidly than the soya bean, but at times it has been used foolishly with unfavourable results. Feeders have made the mistake of assuming that this bean and its by-products contained the same percentages of proteins as are contained in the English horse bean but actually the soya bean contains nearly double the amount found in the English bean. The soya-bean products must therefore be fed at approximately half the rate that ordinary beans could be given to livestock. The soya-bean products are palatable and may be given in moderation to

cattle, horses, sheep and pigs provided adequate carbohydrates are always supplied to balance the ration. Periodically soya-bean meal is used to replace fish meal in the feeding of pigs; when this is done minerals must also be added because, although soya-bean products are rich in phosphates, they are low in lime and considerably lower in both these essentials than fish meal. Both extracted and ordinary forms are commonly offered for sale, the former being used in poultry rations.

Palm Kernel Cake and Meal.

A few years ago the palm kernel cake was popularized particularly for use as the sole concentrated food for feeding to pregnant dry dairy cows to "steam" them up for their next lactations. Since that campaign the palm kernel cake has always sold at a higher price per ton than previously. Even now it is quite sound, financially, to use this cake which has an analysis of 4 parts starch equivalent to 1 part protein equivalent, that is the food is balanced for feeding to dairy cows. The palm kernel cake is not very palatable and it should be introduced into a ration slowly; this slight unpalatability should not, however, deter one from giving the cake to dairy cows of both low and high levels of production. In Europe the popular opinion among farmers is that palm kernel cake, with a high oil content, will stimulate butter-fat production and so increase the butter-fat percentage in cow's milk. There may be some truth in this idea, which is increased by the fact that recently several research workers have shown that certain pure vegetable oils when added to a balanced ration may increase the output of butter-fat. Although most of the palm kernel cake used in this country is fed to dairy cows a certain amount can be given to calves over 6 months of age and to sheep and horses, but when it is fed to stock out of doors care must be taken to keep the troughs sweet and also to see that the store of cake is kept dry; when moist the cake is very unpalatable.

The meal is used for feeding to pigs but the quantity should be kept low, say 10 to 20% of the ration for sows and for pigs in the later stages of fattening; it is unpalatable to pigs and seems to cause irritation in the stomach which is usually accompanied by acute diarrhœa, if large quantities are fed.

Coconut Cake.

Coconut cake may be light yellow in colour, almost white, or it may be quite dark brown; the light-coloured cakes have the higher feeding values. The coconut cake is also balanced for feeding to

dairy cows for milk production, but it is not very palatable and even when only fed as a small proportion of a mixture its flavour is so potent that often cows detect it and refuse to eat any of the mixture. The cake readily takes up moisture from the air and becomes rancid. It is very doubtful whether it is worth while for a farmer to buy the coconut cake to add it to a home-made mixture; on the other hand it may be incorporated, by manufacturers, quite satisfactorily into balanced cubes for dairy cows. Continental (European) authorities consider that the use of coconut cake in rations for dairy cows increases the butter-fat content of the milk, but this has not been confirmed by experimental work in this country.

It must be admitted that many concentrated food-stuffs have been omitted above but space would only permit of the discussion of the most common feeding-stuffs used in this country.

Succulent Foods.

Foods that contain over 70% of moisture are usually called succulent foods or succulents; frequently they contain even a higher moisture percentage, sometimes reaching as high a figure as 90%. The succulent foods are usually laxative; they are valuable for all animals but they are especially useful for live stock giving birth to young, and also for stock that are ill. Natural laxative foods are always preferred to medicines. Usually it is assumed that the moisture in succulents is there naturally and not added artificially as by the wetting of such a food as dried sugar-beet pulp, although the latter may be considered to be a succulent. Several foods that are a by-product from industry that might be considered to be succulents have already been described, e.g. wet sugar-beet pulp, brewers' and distillers' grains and the various milk products.

Cabbages.

In addition to the cabbages that are grown especially for stock feeding it is quite common to find cabbages that are grown primarily for human consumption being given to live stock, either when the prices are low in the spring, or when the cabbage stumps are allowed to produce a second, and sometimes a third, crop of "hearts." The cabbage is richer than is sometimes imagined for it usually contains more nutrients per pound than roots. Quite commonly cabbages are consumed on the field, where grown, by sheep being folded over the crop; thus the crop is utilized cheaply and economically. Cab-

bages, depending on variety and locality, can be available from May till December. Various classes of sheep may receive the cabbages, e.g. fattening lambs, ewes being flushed, suckled or fattened. Ewes often consume up to 20 lb. of cabbages daily especially when suckling. Cabbages are often more convenient for feeding to fattening old "crones" because the leaves of the cabbages are not so hard for the teeth as many of the roots that are given to such fattening sheep.

It is possible to cut cabbages and feed them to cattle, pigs and occasionally to horses, either indoors or on pasture, but cabbages do not keep well after they have been cut so that they must be given fresh to stock almost daily. A green food like cabbage may be given to housed suckling sows to provide iron which is supposed to prevent scour in the piglings. Care must be exercised when feeding cabbages to dairy cows, because this food is likely to produce a taint in the milk and they must be fed in small quantities and then only just after milking times.

Carrots.

It is very rare, that carrots are grown as food primarily for stock but whenever the price is bad, or when the crop is sold on contract and the small carrots are left on the farm, a certain amount is available for stock feeding. Sheep, horses and pigs will eat and enjoy carrots but usually they are given to dairy cows because it is well known that they improve the colour of the milk and cream, or to stud horses because they improve the appearance of the horses' coats. The high carotene content of carrots is responsible for improving the colour of the milk. The law prevents one from adding colouring matter to cream or butter during processing but it is quite legitimate to influence the colour by the rations fed.

The above refers to the ordinary carrots, but sometimes farmers grow the yellow or Belgian carrots, because of the bigger yield this variety usually gives. The actual food value of this carrot is about the same as the ordinary carrot, but of course the carotene content is much lower in the Belgian carrots since the pigmentation is very much less.

Kale.

Kale is commonly grown in the south of England but farther north where the winter is colder less is grown. Marrow stem kale gives the greater yield but it is not as winter hardy as the thousand-headed kale; thus on farms it is quite common to see both kinds

grown, the marrow stem being used before Christmas and the thousand-headed between Christmas and Easter. Kale is usually grown primarily for sheep feeding and it is available for a long period, namely from August to April, depending on the variety and the time of sowing. The crop may, however, be fed to all farm animals, for which purpose it is gaining popularity on account of the big yield of food-stuff obtained per acre, especially with the marrow-stemmed kale (yields of 20 tons per acre are common and over 30 tons have been reported).

The marrow-stem kale produces a very thick succulent stem which has a hard fibrous cortex which sometimes makes it difficult for stock to eat the stem completely: to reduce the thickness of the stem and to assist the sheep to consume the crop thoroughly it is quite common to find this kale grown in rows unsingled, but usually where the aim is to green-soil the crop (i.e. cut it and carry it away for feeding elsewhere) the plants are singled to distances of about six inches apart. If kale is to be fed to housed stock much wastage will ensue unless the crop is cut up into small lengths by hand or by means of a modified "chaff" cutter. This cutting facilitates the consumption of the stem and prevents the stock from treading much of the food into the litter, and so wasting it.

The thousand-headed kale is grown primarily for sheep feeding between Christmas and Easter, at which time ewes will be suckling their lambs and there is no food which is more suitable for this purpose. With thousand-headed kale the lambs can easily consume the shoots that are so numerous on this kind of kale.

Kohl Rabi.

Kohl rabi is available for feeding between August and March. It is very safe for feeding to cows, in the event of drought in the late summer, and because it does not produce a taint in the milk. Sheep may be folded on the kohl rabi to flush breeding ewes, or to fatten lambs; it is highly valued in studs for feeding to brood mares. It is common practice to feed kohl rabi whole no matter what class of stock is receiving it.

Lucerne.

On a certain number of farms, that have a well-drained soil containing a good proportion of lime, lucerne is grown either for stock feeding, or in the pasture replacing wild white clover in conditions too dry for the latter. As lucerne will stand a certain amount of drought; it is usually grown for green-soiling in the months of July,

August and possibly September, when it is fed to cattle and horses on pasture and to horses, pigs and young cattle that may be housed. It is difficult to keep housed cattle feeding during hot weather and lucerne is definitely palatable for feeding at such a time. On account of its unusually high mineral content (both lime and phosphorus) lucerne is a valuable food for housed suckling sows. Its value is so much esteemed that lucerne is being dried on factory lines and the dried meal is being sold for incorporation into the rations of housed suckling sows and also of fattening pigs; for such stock only some 2% of the pigs' ration is lucerne meal. In a similar way, and with a similar object, lucerne meal is included in poultry rations.

Mangolds.

Some five different types of mangolds are commonly grown in this country for stock feeding. Of these types the yellow globe has the highest water content and the lowest starch equivalent. The richest mangold is the Kersche's Ideal which has a very high dry-matter content and in consequence it keeps sound until very late in the season. No variety or strain of mangolds is safe for feeding to live stock till after Christmas because before that time the roots contain a high proportion of amides, which, when given to stock may lead to digestive disturbances. After Christmas mangolds are a very good food and produce no taint in the milk of dairy cows; with bullocks and sheep a peculiar trouble occasionally occurs. When castrated sheep or cattle are being fattened on rations containing mangold, especially when the mangolds have been grown on chalk soils, urethras are liable to become blocked by the formation of calculi. This trouble only occasionally arises with males fattened on mangolds grown on chalk soils. Formerly mangolds were given in absurdly large quantities (224 lb. per head per day to cattle fattening in yards), but at the present time many farmers would not give more than half that amount to their stock. It has been shown that for most breeds of dairy cows 40 lb. of mangolds daily give the optimum results. When enormous quantities of mangolds were given to cattle it was the custom to pulp the roots but at the present time, usually, the roots are merely cleaned and given to stock whole. Mangolds may be given in moderation to calves, as soon as they are 3 months old, with absolute safety. Sheep are never folded on mangolds because the latter are not ready for feeding till the weather is so bad that it might damage the roots if they were left exposed in the field; usually the mangolds are carted to arable land to eke out a crop of cereals or seeds in early spring or fed as an ad-

junct to grass. It is only when mangolds are being given in very large quantities to cattle and to old ewes, with bad teeth, that it is worth while pulping the roots prior to feeding.

Mangolds may be given whole to working horses in winter to keep the bowels open and to reduce the quantity of cereals in the ration; this is commonly done whenever the price of cereals is high and especially in Fenland districts where mangolds grow abundantly. In a similar way mangolds are given whole to sows while pregnant, and suckling, and occasionally to fattening pigs, to replace cereals, in which case 1 lb. of barley meal is equivalent to some 10 lb. of mangolds.

Maize.

In a few districts in this country maize is grown for feeding as a green-crop in the months of August and September; it cannot be depended on after that month because it is very sensitive to frost attack. Most farmers, who grow maize, do so with the intention of feeding it to dairy cows when the grass is poor either through drought, or on account of the advancing season. Maize may be fed to housed stock but it should be cut into short lengths to reduce wastage; if given whole on pasture stock will clear it up well. If any maize is not consumed by the end of September it is possible, with suitable equipment, to cut it up and make it into silage. Excellent silage can be made from maize and the feeding of this product will be discussed later.

Potatoes.

Whenever main-crop potatoes sell for low prices for human consumption a quantity is always used for stock feeding, and every year chat potatoes and surplus ware potatoes are either used for stock or artificially dried for use for animal feeding. Three varieties of dried potato products are known, potato cossettes, which resemble dried sugar-beet pulp in appearance, potato flakes, which are made from steamed potatoes dried off on a hot drum roll, and potato slices, produced at the sugar-beet factories from sliced potatoes passed through the Buttner driers. In the manufacture of the potato slices, the potatoes are subjected to a much higher temperature than in the production of cossettes, and so undergo a thorough cooking as well as a drying process. Woodman and Evans have investigated the feeding value of these products, and on the basis of digestion trials have found that all three forms of dried potatoes when fed in a balanced diet are superior to barley meal in feeding value and

are markedly superior to ground oats for pig feeding. Potato slices compare favourably with maize meal, and potato flakes with flaked maize. Inclusion of the ground cossettes (potato meal) in more than moderate amount in pig rations gives rise to digestive disturbances and scouring, so for pig feeding the farmer is advised to use either the potato flakes or potato slices. Judged on digestion trials, pigs make more efficient use of these products than sheep, but it is considered that, in a balanced diet, all these three products can be regarded as in practice as suitable for replacing barley in the rations of cattle and sheep, on a pound for pound basis. Since the flakes tend to become pasty during mastication in the case of ruminants, it is considered that the cossettes and the slices are more suitable for inclusion in the rations of sheep and cattle. Potatoes are given most commonly to fattening or breeding pigs to replace barley meal, 4 lb. of potatoes for 1 lb. of barley meal, but for safety the total quantity of potatoes fed to a pig should not exceed 16 lb. daily. To obtain the best results potatoes should be cooked prior to feeding them to pigs. It is very rare to give potatoes to sheep but they may be given to cattle and cows ; this must be done with very great care because it is easy to kill the stock by allowing them to become blown. It seems that mature cows may eat 20 lb. of potatoes with safety but it must be remembered that if the potatoes are given to the stock in yards the greedy ones eat more than their share and may suffer harmful effects. Students are reminded that potatoes are very high in starch equivalent (18%) compared to other roots which contain about 7%.

Silage.

It is possible to make silage from combinations of cereals, legumes, grasses, from many of these crops used by themselves, and also from various by-products. Sometimes silage is made in a tower silo, sometimes in a clamp and occasionally in a stack; various temperatures are produced and sometimes acids, or molasses, are added to the material. With all the above modifications of procedure, and crops used, it is obvious that silage is not a feeding-stuff of uniform composition although many speak of it as though that were the case. Starch equivalents may range from 8 to 36% and protein equivalents from 1 to over 8%. It is obvious that it is impossible to discuss each class of silage separately; suffice it to say that provided it is properly made silage is an excellent food which may be fed advantageously in conjunction with appropriate supplements, to cattle and to sheep. Silage is slightly laxative, it is exceedingly palat-

able when it is made properly, and young cattle, in particular, do very well on it; their coats usually show excellent bloom, even when small quantities are given daily. It is very doubtful whether it is desirable to feed more than 40 lb. per day to any cattle, although in Holland 70 lb. are quite commonly given to dairy cows. Some practical men consider that silage produces a taint in the milk of dairy cows, but this is through mis-management for the taint is carried in the air where the silage is fed and provided the silage is fed in some shed, or yard, other than where the cows are milked, no such difficulty will arise. Silage is quite suitable for feeding to sheep but as the sheep are usually out in the fields, whereas silage is made at the homestead, it follows that it is often inconvenient to give silage to sheep. When clamp or stack silage is made in the fields then the resulting silage may be fed to sheep. A little silage may be given to horses and sows but it should never constitute a big proportion of the ration of any pigs unless of course potato silage has been made, and this is a first-class food for pigs. Potato silage is also given to poultry.

Rape.

In some districts in the south of England rape is frequently grown as a catch crop, being drilled late in the spring, or even early in the summer, and it being ready for feeding three months after drilling. Its analysis is very similar to kale but it contains a little less starch equivalent than the kale; further, it is not wise to feed rape to dairy cows since it frequently produces a taint in the milk, whereas it will be remembered that kale may be fed quite safely. Rape is grown essentially for sheep but a certain amount is sometimes given to housed pigs. It must be emphasized that rape is a very quick-growing plant, and quick-growing plants are usually laxative, and rape is no exception; great care must always be exercised when first putting sheep on rape, and for safety, the ration must be kept at a low level in the initial stages of feeding by allowing the sheep smaller folds than normal.

Swedes.

There are several varieties of swede that are commonly grown and in general they are fairly winter hardy. In the south of England they may be left in the fields throughout the winter for sheep feeding but in the north for both sheep and cattle feeding they are usually lifted and stored to keep them safe for feeding. The swede is nearly twice as nutritious as the turnip, but even the swede falls considerably

short of the kale. Swedes may be given in large quantities to fattening cattle but it is very doubtful whether this practice is wise from an economic standpoint. Whenever as much as 112 lb. of swedes is fed daily to fattening cattle it is essential to pulp the roots to facilitate the consumption of such a heavy ration. When swedes are given to dairy cows there is always the danger that milk may be tainted; this is an internal taint and not a case of the milk absorbing the odour from the atmosphere. For sheep swedes are excellent food and are grown pure for folding or perhaps with four or six rows alternately of swedes and kale; occasionally these seeds are mixed. This method of sowing in strips is to ensure a crop in the event of something failing and also to ensure folding over the whole field lest one crop is lifted and carted away.

Sugar-beet Tops.

Few farmers seem to realize that sugar-beet tops are an exceedingly valuable food, having an analysis equal to that of kale, and, in general, producing the equivalent of a full crop of white turnips or a half crop of kale per acre. On a number of farms this by-product is often ploughed in, but it may be used as a stock food either green or ensiled alone or mixed with chaff or beet pulp. Both the tops and the silage may be given to cattle and sheep, but care must be exercised when feeding the tops to ensure they are wilted 2 to 3 weeks prior to feeding. If wilting is impracticable then it is possible to counteract possible trouble, since the green tops contain oxalic acid, by giving the stock access to chalk. Experience shows that both sheep and cattle will eat the chalk quite readily if it is placed before them. Sugar-beet tops may be fed in large quantities to bullocks being fattened in yards—112 lb. being used with absolute safety, but it is obvious that it is desirable to feed the minimum of soil with the tops, and care may have to be exercised at lifting time to keep the tops as clean as possible. The tops may be carted off for feeding to housed cattle, to cattle still running out at grass, or for making into clamp silage; no matter for what purpose it is being carted the minimum of soil should be taken on the leaves and crowns. In some European countries the sugar-beet tops are collected, washed and dried and the product is used for stock feeding; in October 1937, a factory started drying sugar-beet tops in the Eastern Counties of England but it is premature to discuss the value of the product.

Turnips.

From the point of view of nutrients turnips are the poorest root grown for stock feeding; as the actual yield is usually lower than that obtained from other kinds of root crops it is largely because of their speed of growth, and that they produce food at awkward times, that some farmers still grow the crop. Turnips grow very quickly and will provide food in the winter or in the spring even if planted after cereals have been removed, for this purpose turnips have no equal. When turnips are drilled in the spring as an ordinary root crop they are ready for folding for sheep in the early autumn; on the other hand they may be left in the ground till the spring when the tops will sprout freely. At that time the roots become very tough and they may be wasted when sheep are folded on the field. Turnips should never be given to dairy cows in milk because they frequently produce a taint in the produce; turnips are quite safe for feeding to cattle but it is doubtful whether it is satisfactory to grow them for this purpose, because they are small roots to lift and both yield and quality of food are low.

Roughages.

It will be remembered that the succulent foods are spacious because of the large amount of water they contain; the roughages are bulky foods because of the high fibre content; the roughages usually consist of 30 or 40% of fibre, a large proportion of which is indigestible. The feeding value of the roughages varies considerably, depending on the state of the crop when cut, e.g. for hays whether cut before, during or after flowering, and also upon the storing of the crop and the amount of heat developed; it is, therefore, difficult to speak of the food values of roughages in general terms. Usually the roughages have a binding action on the bowels, but sometimes for some inexplicable reason, hay may have a laxative effect; experience shows that no inspection of the hay will betray that it may have any unusual effect on the bowels. New season's hay is liable to cause digestive troubles if fed in large quantities before Christmas. Cattle, sheep and horses can utilize large quantities of fibrous foods because they have large digestive systems especially adapted for this purpose; on the other hand pigs and poultry are unable to digest bulky fibrous foods and roughages are not normally included in the rations of these stock. Usually better-quality hays are given to racing horses, dairy cows, fattening sheep and cattle, whilst store stock and breeding sheep and beef cattle usually receive

the poorer-quality roughages. Normally a discussion of roughages would commence with a description of meadow hay but since that is more conveniently included in Chapter VI, only the hays from arable land together with the various straws will be discussed here.

Clover Hay.

Various strains of clover are grown commonly in this country; some will give several cuts, or the equivalent, a year whilst others give one cut only. Crimson clover falls into the latter category and the cut it gives is obtained towards the end of May; if the cut is made later then the hay is coarse and very fibrous, and, even when made properly, the feeding value of crimson clover is not very high. The crop is usually grown as a make-shift when it is discovered after harvest that other seeds have failed, for it is possible to put in crimson clover on the stubble and obtain some crop. The hay is usually given to horses (working) and to breeding cows but other kinds of hays are better for both classes of animals. It might be added here that the green crop is quite commonly folded off by sheep in late May. Of the other clovers Broad Red is frequently grown pure and made into hay in June; in many districts a big second growth is available by August for a second hay crop, for seed or for sheep folding; the latter being a useful food for lambs, or for flushing ewes, but if the aftermath is given to the sheep at a wet time it may cause trouble by making the sheep blown. The hay, if well made, is an excellent food for horses (working and breeding), for sheep and for fattening cattle and dairy cows if free from dust. Other forms of red clover are less frequently sown pure, but may be used as the pure red clover hay.

Occasionally white Dutch clover is grown for sheep feed or for hay; the yield is lower than from the red clovers and the quality of produce is little, if any, better. The uses to which the hay is put are exactly the same as for red clover.

Lucerne.

On either well-drained soils or on the chalk soils lucerne will usually grow well in a ley for 4 to 8 years, in such situations it is grown either for green-soiling during periods of drought or for making into hay when not required green. Lucerne hay is very variable in food value because the fibre content increases rapidly just as the plant commences to flower and if cut late the fibre content is exceedingly high; further the leaf, which is the most nutritious part of the plant, is very liable to fall off during hay-making and if that is lost then the value of the hay is very much reduced. The good-

quality hay is excellent for dairy cows, young growing cattle and for young horses because it is high in proteins and also in both calcium and phosphorus. On analysis some of the best hay is equivalent to some of the poorer concentrates and so will lead to economies in the cake ration of dairy cows.

Italian Rye Grass.

On Fen soils and often on sewage farms Italian rye grass is grown pure for a hay crop; in these places big yields of hay are obtained per acre. Pure Italian rye grass hay has quite a high starch equivalent but it is definitely low in protein equivalent. The pure rye grass hay is usually given to working farm horses and they will do well on it.

Much more commonly Italian rye grass is sown with red clover and then the mixture is frequently referred to as seeds hay. This mixture of rye grass and clover produces a hay which is very useful for horses, sheep and all cattle except perhaps the best dairy cows. The aftermath makes excellent feed for arable land sheep.

Sainfoin.

Two strains of sainfoin are grown in this country but they are not quite as distinct as might be anticipated; the one, giant, gives two and sometimes three cuts for one season alone and the other, common, gives one good cut each year but persists for several years. (The aftermaths are used for arable sheep for fattening lambs and for flushing ewes and are considered to be the best food ever available for such sheep.) Sainfoin deteriorates rapidly in nutritive value as flowering proceeds, and if hay is to be of the highest quality the crop should be cut when the majority of the crop is just coming out in flower. If cutting is delayed the resulting hay is very woody. Good-quality sainfoin hay may be as good, from the feeding point of view, as lucerne hay except that the mineral content will be slightly lower. The best quality sainfoin hay sells for high prices to breeders of race horses in some localities for it is apparently the best kind of hay for brood mares, it is difficult to understand why this is so, but such is the belief of the breeders. Normally good sainfoin hay is considered ideal for all kinds of farm horses, and for fattening and milking cattle, whilst the poorer quality will be good food for breeding sheep and the poorest for store cattle.

Tares or Vetches.

In this country it is unusual to find tares grown without a supporting crop because of their weak stems which result in the whole crop being laid flat often before it is sufficiently advanced to be cut. Normally, when hay is to be made from tares, oats are sown in the mixture, or, on very light soils, rye may be used, but in both of these cases the tares must be drilled with a light seed rate, otherwise they will drag the cereal to the ground. The addition of the cereal to the tares reduces the food value of the resulting hay as compared to that of the original tares alone, principally by reducing the percentage of proteins; on the other hand, bad weather at hay-making time may ruin pure tare hay. Good oat and tare hay is not quite so nutritious as good clover hay, but a bigger yield of digestible food may be obtained per acre from the oats and tares than from the clover. There is one disadvantage, however, that should not be forgotten, namely that there is little, if any, second growth from the oats and tares but a big second growth from some of the varieties of clover; this is an important consideration on farms where sheep are kept on the arable land. Good oat and tare hay makes excellent roughage for dairy cows and working horses.

Trefoil.

In the Eastern and Southern counties of England trefoil (Medicago lupulina) is quite commonly grown on the light, and especially chalky, land. In these cases it is grown for sheep fed in early May and if not required for that purpose it is allowed to ripen for seed production. On heavy clay soils trefoil is included in seed mixtures where hay is to be made and where bastard fallowing follows the hay crop. Trefoil hay is rarely made pure because the crop is more valuable for other purposes and also because the hay produced is often of a fibrous nature and only a small yield is obtained per acre. A disadvantage of growing trefoil is that it produces no second growth or aftermath. In view of these disadvantages the crop is only grown on a limited number of farms.

Seeds.

The name seeds or seeds hay is usually used very loosely and may be taken, in its widest sense, to include all kinds of hay grown on arable land. On the other hand many people consider seeds to consist of a mixture of Italian rye grass and red clover with, in some cases, other clovers and grasses added. The Italian rye grass and red clover mixture will usually give a heavy cut, often well over

two tons per acre of high food value. The seeds hay will make excellent food for horses, and, if not of the best quality, for store cattle.

Straw.

Whenever cereals, grasses and legumes are allowed to mature in the field for the seed to ripen the nutrients of the plant will pass, in general, from the stem and leaves into the seed with the result that when the seed is threshed out of the remaining material, the stems and leaves, or straw, has a low food value. As the stem usually contains less food value than the leaf, a low proportion of the latter, through a bad condition at harvesting or threshing or through variety, will reduce the food value of the straw. Further the degree of ripeness, or the extent to which the plant foods have passed from the stem and leaf into the straw, will influence the nutritive value of the straw. Even the best kinds of straw are poorer in food value than the majority of poor-quality hays and they are frequently rather unpalatable, but stock, especially store cattle, are often forced to eat the straw by withholding other food. Grass and clover straws have been omitted since they are not very widely grown.

Barley Straw.

All the cereals contain little proteins but barley straw may include a certain proportion of clover where seeds have been undersown; this naturally increases the protein value of the straw. Barley straw is the richest of the cereals in starch equivalent but even so it cannot be recommended for feeding to fattening stock because of its relatively low feeding value. Barley straw has to be given with care to stock because of the awns which easily enter animals' eyes and are very difficult to extract owing to their serrated surfaces. For safety barley straw should never be fed from high racks but preferably low down to reduce the risk of the awns giving trouble. Barley straw may be given in large quantities to store cattle and to dry dairy cows with the object of reducing costs and of satisfying the animals. In winter store cattle may easily consume up to 30 lb. of barley straw daily and do quite well provided they have a good supply of water available and receive 3 lb. of high protein cake daily. For high-yielding dairy cows and for fattening cattle, barley straw is of doubtful value, but for low-yielding cows (when giving under 2 gallons a day) a certain amount may be used in the maintenance ration; usually such stock are allowed to feed at will on the straw because it is considered to be soft and easily consumed by cattle.

Bean Straw.

To the casual observer bean straw appears to be far removed from a food but actually it is surprisingly nutritious; this is because of the leaf and pod present and not on account of the food value in the actual stems. Only two kinds of straw contain more protein equivalent than bean straw and they are peas and vetches, and even these latter do not contain such a high starch equivalent as that found in the bean straw. It is not intended to suggest that bean straw is an ideal food for highly productive stock but experience shows that it may be given advantageously to store cattle, both beef and dairy, between the ages of 1 and 2½ years and also to housed beef-breeding cows. For these classes of cattle the straw should be given freely in order that the stock may select the most nutritious part of the food and leave the stems which may be trodden down into manure. Experience shows that commercial beef-breeding cattle may live with absolute safety through a winter on bean straw, water and 2 lb. of a high protein cake.

Oat Straw.

As the oat plant is usually cut before the plant is fully ripe there is a fair amount of nutrient still left in the straw and leaves; this oat straw, especially when the seed has been spring sown and when certain varieties have been grown, is quite good food value. It may be fed, without injury to eyes, to store cattle and in limited quantities to dairy cows and to fattening cattle. In some localities, where hay is scarce, oat straw is the main roughage for fattening cattle but where hay is available it is a better food for fattening stock than oat straw. In Scotland, where oat straw is widely fed to cattle freshly threshed straw is considered to be of higher food value than straw that has been threshed for some time. Sheep may be given oat straw to pick over in winter when the supply of grass is short. Young and breeding horses and working horses, when not working hard, may be given oat straw in the long state; many farmers chaff oat straw for feeding with the concentrates for horses to ensure adequate chewing. In some districts oats are fed unthreshed to save the cost of threshing and also to reduce the risk of stock "bolting" the grain.

Pea Straw.

The straw from the field pea contains a higher percentage of protein equivalent than any other kind of straw grown in this country and may be equal in food value to some of the poorer kinds of hay. Pea straw is very popular amongst shepherds for feeding to pregnant

ewes during the winter time whether on grass or on roots, and if it is in good condition then it may be given to ewes after lambing on the arable land. Apart from this rather special use the straw may be given as other straws to store cattle; it should be remembered that the straw must be fed with care because it is very liable to become mouldy on storage.

Rye Straw.

The food value of rye straw, which contains a very high percentage of fibre, is so low that this straw is never fed to farm animals, instead of which it is used for litter, thatch, for making into horse collars, and in commerce for packing crockery.

Wheat Straw.

Wheat straw is another straw of very low food value for it contains a high percentage of indigestible fibre, and very little nutrients. Wheat straw is so valuable for litter, for thatching or for sale to industries (for packing material) that it is not as a rule fed to farm animals.

Miscellaneous Straws.

In addition to the straws described above there are a number of others produced from time to time in various parts of the country. Most of these straws are obtained when clovers and grasses that are grown for seed are threshed; in these cases the food value is low but variable, depending on the amount of leaf remaining attached to the stem. A warning should be given that the clover cosh or husk may be a very dangerous food to give to cattle because it is very constipating. Some farmers have killed stock by feeding them with it, and they advise using it as litter. Linseed straw is much too fibrous for feeding to livestock, but sometimes the chaff contains quite appreciable quantities of the seed. This may be fed with care to store cattle. These straws may, in general, be given to store cattle and beef-breeding cattle and so constitute the major portion of the bulky ration.

VI

USES OF GRASSLAND AND ITS PRODUCTS FOR LIVESTOCK

THE term grassland is used very loosely, for it may be given to land carrying a mixture of valuable grasses (i.e. from the animal nutrition viewpoint) or it may be given to a bog or to a mountain carrying but a sparse covering of poor grasses. The grassland of this country is so variable that during the summer the best will fatten one bullock and one sheep to the acre, without any concentrated foods being used, whereas some of the "so called" grazing under mountain scree conditions demands several acres even to sustain a very small sheep, and then it will not be possible to fatten any sheep till they are three years old, which, at the present time is uneconomic. In addition to these very obvious variations in grazing land marked differences may be found from one field to another on the same farm; whereas one field may be first class land for fattening bullocks an adjoining field may be suitable for store cattle only. Experience rather than botanical composition will give the greater amount of information about the stock carrying capacity of a pasture. On the other hand the botanical composition is important because certain species are particularly valuable to farm animals whereas others are not consumed at all by stock; such species unless especially checked may ultimately dominate the pasture. Good pasture is a mixture of the right species present in the correct proportion; by skilful management, which includes controlled grazing, the use of the mowing machine, good drainage, and by adequate manuring, a good sward may be maintained. Since the species play such a big part in the nutritive value of grassland it is essential to explain the importance of these species most commonly found in grassland.

Of the components of pasture perennial rye grass is very important for all livestock because it grows vigorously throughout most of the year; it remains green in the winter and makes more growth than any other species. Cocksfoot is a good servant but a bad master, for if it is managed properly it will give an abundant growth in spring and also a good aftermath, but if it is mismanaged it will

spread rapidly and dominate the sward. Good management of cocksfoot involves grazing down thoroughly with stock, especially with sheep, whenever the growth of grass is taking place very rapidly; if cattle only are used for grazing, they do not graze it closely with the result that the grass sets seed and in a few years dominates the pasture. Cocksfoot makes no growth in most winters and assumes a burnt appearance with the first hard frost, it is said to "winter burn." On heavy soils timothy is a valuable grass because it is not aggressive yet grows most freely, namely in July and August, at which time many species make little or no growth, and when, in dry districts, grass is scarce. Of the meadow grasses both smooth and rough stalked are of value because in addition to providing food they fill in the bottom of the sward and reduce the amount of bare ground. This produces two important advantages, it reduces the incidence of poaching in the wet weather and in dry weather reduces the loss of water by evaporation thereby increasing drought resistance. These meadow grasses by making a sward help in keeping out weeds. The fescues are all slow growing fibrous grasses that provide very little food for stock; these grasses are most valuable for sheep grazing land as is also, according to some authorities, crested dogstail. Of the various clovers that may be found on grassland none is equal to wild white clover, on most kinds of soils, for persistence, productivity and food value. Occasionally a pasture may contain too much wild white clover as is evidenced by the scouring of the stock or by their tendency to become blown when grazing during a wet period or at times of heavy dews; most pastures, however, do not carry sufficient wild white clover. The growth of this very valuable clover is limited to the summer only, when it reaches its maximum productivity in June and in July; although it survives the normal winter experienced in this country, it is very inconspicuous during that period. On newly laid down pastures late flowering red clover and alsike may be highly productive during the summer grazing period, but these species will not persist in any appreciable quantity for more than about three years. On light soils containing an abundance of lime lucerne is sometimes sown as the chief legume; under suitable conditions it will grow freely and produce large quantities of summer food for a period of some six years. At the present time it is not usual to sow chicory, yarrow and burnet in pastures for these plants are looked upon as useless weeds, yet they were often included in mixtures sown down before the World War (1914–18). A number of grasses that grow freely on some grassland may be considered to be weeds because they are so very unproductive of valuable foods,

e.g. the bromes, barley grasses, watergrass (bent) tussock grass and Yorkshire fog. Certain weeds are found in large numbers in most grassland areas, e.g. thistles of various kinds, nettles, daisies, buttercups; others are found more especially in heavy land, e.g. watergrass, sedges, horsetails, rushes, brambles and thorn bushes; bracken, sorrel and heather grow on lime deficient soils whereas thyme, stemless thistles and burnet grow on the chalk soils. Most weeds are not very nutritious, occupy space and take plant nutrients and water that could be better utilized by grasses and clovers. Some weeds are very poisonous to livestock, e.g. some of the buttercups, ragwort, horsetails, whilst others are merely suspected, e.g. mayweeds, silver weed, dodder and yellow rattle. It is well known that wild onions, yarrow and some of the camomile species may cause taints in the milk, and milk products, when consumed by dairy cows either with grass or in hay. Many of these weeds are not ordinarily consumed by live stock but at times of drought, when the usual grasses and clovers are scarce, animals are frequently forced to eat these dangerous weeds and it is at such times that these weeds give the most trouble.

It may appear irrelevant to discuss the management of pasture in this book, but grass is such an important stock food that it is essential to describe which features of good management are responsible for improving a poor sward and for maintaining the sward in good condition. Although grass can be the best food for livestock it may easily become by mismanagement one of the worst. Some farmers consider grazing calls for no skill and consequently in spring stock are turned into a field and more or less forgotten till the autumn when they are removed; in such cases stock often do badly and the pastures deteriorate. Without any doubt grazing is the most important feature of management for if the grass is made to grow by manuring it must be consumed or otherwise the pasture will deteriorate through the manuring. Good grazing includes grazing at the right time, i.e. after growth has well started in spring and before there is so much growth that the grasses are coarse and distasteful to livestock; it includes grazing with sufficient stock so that they may master the growth without suppressing it; it comprises removal of stock when they will do damage by poaching the surface, i.e. in wet weather or in winter; it also necessitates grazing with various kinds of stock. It is well known that the various farm animals have their characteristic ways of grazing, e.g. the horse grazes very close to the ground and eats in one part of a field and discharges all waste products in another; sheep also eat

very close to the ground whereas cattle eat the taller grasses and clovers, the pig, unless carefully ringed routles, whilst chickens scratch. Unless poultry and pig houses are moved at frequent intervals when on pasture, droppings accumulate around the houses and coarse rank grasses quickly appear. It is a well-known fact that livestock will not graze very near their own droppings; if one kind of stock is kept in a field throughout a grazing season rank growth will develop around their droppings. That droppings lead to coarse growth of grass is well realized in the Midland pastures, where, on some of the best grassland, the dung is either collected by cart at frequent intervals during the grazing season and redistributed during the winter, or spread by hand more or less daily throughout the grazing season. If, on the other hand, stock are mixed, e.g. sheep and cattle or horses and cattle they either graze together or alternately; provided sufficient of the various stock are used, the sward and nutritive value may be maintained or improved. Good grazing often demands forcing the stock to consume rough grass; this is only practicable when the fields are relatively small (not more than ten acres) and then all the rough grass must be consumed—even the patches. The right animals must be selected for such grazing otherwise trouble may ensue; hungry store bullocks are the ideal stock, on thè other hand dairy cows in milk are unsuitable because forcing them to eat coarse grass results in a fall in their milk production. In some seasons during May, June and July,.when growth of grass is very abundant, a farmer may have insufficient live stock on the farm to consume the grass as rapidly as it grows, then it may be necessary to resort to a mowing machine. To prevent the sward from running to seed, becoming unpalatable and producing grass of a low nutritive value it is desirable to cut the herbage to make the plants throw up fresh palatable and nutritious shoots. A light cut of such material may be left on the field, for experience shows that stock will consume the trimmings whereas they will not eat the same material when still growing. If, on the other hand, there is a heavy cut it may be worth while collecting it and using it for topping up a stack, and so preventing good hay from being spoilt, because the hay placed right on top of a stack is very frequently spoilt. If a farmer discovers, in early May, that he has more grass than his stock can possibly consume, to prevent the pastures from being undergrazed, he may shut up a further field, or fields, for hay. This will often produce up to a ton to the acre of young leafy hay when cut in June or July and then a good aftermath will be ready for grazing one month after cutting, provided there is sufficient rain after the hay crop has been

removed. This aftermath and hay is much better food than the rough grass that would have been produced from undergrazing the same pasture. Further the closing of one field to stock will usually result in the others being properly grazed; thus the grassland of the farm may be improved by taking hay in the above-mentioned way.

Another method that may be employed to conserve valuable May grass is to make silage either in a stack, in a concrete pit or in a tower silo. Only the latter of these systems calls for the use of expensive apparatus and provided the silage is well made the proportion of wastage at the top and sides of stacks and pits will be small. The actual wastage of nutrients depends more on the temperature reached in silo than upon whether pit or stack silage is made; whenever high temperatures are obtained much wastage of nutrient occurs. Depending on the location of the silage it may be fed to stock housed, or at grass, either in winter or in summer at times of drought. It is, of course, possible to make silage at any time during the grazing season when there is surplus grass.

Grazing cannot be carried out properly and throughout the year if the soil is badly drained and if during wet periods water stands on the surface. Wet areas in a field are characterized by poor growth, and by the presence of unpalatable species that provide very little plant food. Whenever water stands for any length of time on pasture wild white clover and the better grasses, such as rye grass, cocksfoot and rough stalked meadow grass, disappear, and their places are taken by such grasses as watergrass, tussock grass and sedges. When grassland is to be improved drainage is the first operation to be done and subsequently cultivations are frequently necessary. Under many conditions of mismanagement a matted turf is produced; before any manures applied can reach the soil, and so be of value, the mat must be broken. Various implements that are on the market will do this efficiently, but it must be emphasized that the old-fashioned chain harrows merely ride over such a surface and tear nothing out. The pitchpole harrows or the modified chain harrows, that carry a number of cutting knives, must be used to break a mat. It is not sufficient to drag either of these implements over a field once; to break up a mat thoroughly these harrows may have to be used several times, usually both down and across a field, in order to cover the ground thoroughly. Such treatment of the turf makes the field look more like arable than grass land but the ultimate results will astound those who have never witnessed the operations. Good, well-established pastures need some cultivation to maintain productivity; pulling out rough grasses, spreading manure droppings, ant- and mole-

hills; seeds harrows, or using very heavy flexible chain harrows, will usually do all that is required. On some farms it is the custom to roll pastures but usually such light rolls are used, and at such high speeds, that it is very doubtful whether the rolling does any real good. A very heavy roll may make a slight impression on a pasture but it is very questionable whether this is really required.

After adequate cultivations have been done attention may be paid to manuring. It is impossible to make first-class pasture where the soil is deficient in lime, for the valuable legumes will not grow vigorously in lime deficient areas. Chemical analysis of the soil will indicate the amount of lime that should be applied to neutralize acidity sufficiently to produce a sward of the desirable grasses and clovers. The next manure to apply either to improve poor grassland, or as a routine procedure on good grassland, is a phosphatic fertilizer. In the drier districts, and where there is a good supply of lime in the soil, basic slag or superphosphate may be applied at the rate of half a ton per acre at intervals of every four years. In the wetter districts, and especially where the soils are slightly acid, the finely ground North African mineral phosphate should be used, it being applied at the same rate and frequency as slag in other districts. The application of phosphatic manures usually produces big increases in the percentage of clover in the sward, a big reduction in the numbers of weeds and a big increase in the productivity of both grasses and clovers for stock consumption. On some neglected pastures it is possible to double the nutrients produced per acre by the application of phosphatic manures. On a few light soils potash manures are required but since much of the better grassland of this country is on the heavier soils potash fertilizers are less commonly used than are the phosphatic ones. Several years ago nitrogenous manures were being strongly advocated for use on grassland but at the present time their use is less popular. It is well known, that provided there is sufficient rain to wash these manures into the soil, nitrogenous manures will increase the amount of grass produced by a field; experience shows that this may be costly and that, if continued for several years either by giving an annual application or by monthly doses given throughout the grazing season, a change in the botanical composition of the sward will be produced. The chief change in the sward is that the proportion of clover falls rapidly; this may be very serious in the dry districts where wild white clover is the chief species providing food in July and August. The main use of nitrogenous artificial manures on pasture, at the present time, is to provide, either early grass in spring

and so reduce the length of the expensive indoor feeding period, or grass in August, after hay has been taken in June or July, the object in this case being to reduce green-soiling. Occasionally nitrogenous artificial manures are applied to grassland that is to be cut for hay, but much more commonly farmyard manure, or liquid manure, is applied for that purpose. In the grassland districts the animal waste products are commonly used on grassland but in arable districts farmyard manure is usually required for the arable land.

The management of the grazing animals is far more important than is sometimes imagined. If the stock are allowed to graze a pasture too hard in spring, before the roots of the sward have made sufficient growth, the pasture may incur a severe check. Time spent waiting early in a season is not wasted, it will allow the pasture to become better prepared for production throughout the grazing season. Apart from the very beginning of the season grass should be kept grazed fairly short because young quick growing grass is a concentrated food high in protein and carbohydrates. The grass may be kept young and constantly growing throughout the season, weather permitting, by either grazing continuously, the number of stock used being modified with seasonal variations in the production of grass, or by alternately grazing thoroughly and resting for several weeks. This latter system is known as rotational grazing and it was very popular for a short time because of the big yields of grass produced. To carry out rotational grazing six or eight grass fields each of 2 to 4 acres are necessary, every paddock must be properly fenced and provided with water laid on for drinking so that each paddock may be treated separately; sulphate of ammonia is applied to produce an early bite in spring; a large number of dairy cows are grazed for a few days (often three) to eat the best of the grass; dry cows or dairy heifers follow to graze the pasture bare; the field is harrowed to spread droppings and 1 cwt. of sulphate of ammonia is applied; the field is then rested for about three weeks and then the grazing and manuring is repeated as described above. The difficulty with this system is that the manuring, fencing and laying on water are all expensive, and difficulties arise depending on summer rainfall. To allow for a dry season certain paddocks must be kept in reserve, but if the season is wet it is usually very difficult to utilize the grass satisfactorily in the reserve paddocks (hay-making being difficult in a wet season, silage making is possible though better results are achieved if grass is dry when ensiled, grass drying is only practicable on a large farm, and to obtain extra stock to consume the grass would be uneconomic because stock are expen-

sive when grass is plentiful). These reserve paddocks are very liable to deteriorate and since they may represent up to 50% of the area that is being grazed rotationally severe losses of nutrients may ensue. Although the system is difficult to work it includes a sound principle, namely, that it is important to let the grass up once a year to promote root development, but this should not always be at the same time each year.

Many graziers find at the end of summer that their stock have not been able to eat the grass as rapidly as it has been growing with the result that there are large quantities of rough grass on the pastures; this will be particularly noticeable where horses have been the only stock grazing a pasture. If such grass fields are to be as productive as possible in the next grazing season the rough grass must be removed. The only practicable way of using that "grass" is by cattle for only they can cope with it. Perhaps the ideal stock is hungry store bullocks aged over 2 years and of the Sussex breed; experience shows that Sussex cattle are not discriminating grazers and they will eat all kinds of rough growth on pastures. If the fields containing the rough grass are small, stock may be forced to eat the unpalatable grass, but with large fields the situation is more difficult unless a large head of stock is used and even then, with some breeds, they may refuse to eat the coarsest of the grasses. In addition to the benefit to be derived from merely chewing off the rough grass a further advantage obtained by doing so, is, that if manures are applied after the grazing they make better contact with the soil and so are more effective than would otherwise be the case. It must be emphasized that it is bad management to have this rough grass in the autumn, either by design or accident, for its nutritive value is low because the species will have seeded and the chief nutrients of the plant will have passed into the seeds. In some localities it is the custom to leave rough grazing purposely for the autumn and winter, but it would be a much better proposition to make hay and feed it on pasture rather than to allow the grass to become too old before it is grazed. Whenever cattle are grazing in winter care must be taken to see that they do not poach the land, i.e. in wet weather, and especially on heavy soil, the cattle may sink into the turf and leave hoof marks several inches deep. During wet periods it may be necessary to remove the cattle for a time for the sake of the pasture. If this rule is not observed the pasture may assume the appearance of a ploughed field, especially around gateways, and in the spring it may have a very uneven surface. A worse feature may be observed at that time namely, that the botanical composition may

be affected, the clover being killed out and its place taken largely by watergrass or bent; then it may be several years before it assumes a good flora again. Mismanagement for one winter may affect the productivity for many grazing seasons. Care must always be taken to see wherever feeding troughs stand that excessive manuring, or poaching of the field, does not take place; such troughs should be moved daily, and special care must be paid to this feature when stock are being wintered on pasture.

In most cases the main object of manuring and managing pasture is to increase the proportion of clover present; this is principally because of its palatability and high food value, but it may also be because its presence leads to an improvement in the grasses themselves. It is well known that the addition of lime and phosphates coupled with drainage, appropriate cultivation, and controlled grazing, will usually maintain, and often increase, the proportion of wild white clover in pasture. It occasionally happens, however, that there may be an excess of wild white clover present (this is usually most serious because of the succulent nature of the clover leaves and stems making stock consuming them suffer from diarrhœa and sometimes from becoming "blown") and this may lead to difficulties when grazing the field. On these occasions it is necessary to reduce the proportion of wild white clover in the sward; this can be accomplished quite easily by smothering it out by, (*a*) taking a hay crop, (*b*) manuring with artificial nitrogenous manures and encouraging the growth of the grasses, (*c*) heavy manuring with poultry or pigs (which has the same effect as (*b*)), (*d*) inadequate control of the grazing so that large quantities of dead grass are left on the field at the end of the grazing season. It must be emphasized, however, that in general the problem is not normally to discourage the growth and development of wild white clover but to encourage it.

There is another aspect of grazing management that calls for attention, namely the distribution of diseases and parasites by grazing animals. Of all the diseases that cattle can get none are more common in this country than contagious abortion, Johne's disease and tuberculosis. These diseases may be present in a herd and be distributed over pastures long before a farmer may realize their presence. When once these diseases have been spread over a pasture it seems fairly certain that they may be capable of infecting healthy stock grazing there within the next six months. Wherever an attempt is being made to keep cattle free from these diseases no cattle should be permitted to graze infected pastures for a period of at least six months, and for preference twelve months, after infected stock have

been in a field. The utilization of the grass on such pastures becomes difficult but it is fortunate that sheep do not suffer from the same diseases, at least not in the same forms as are found in cattle; thus sheep may be employed to utilize the grass. Another possibility, when the trouble is discovered at the end of the grazing season, is to remove the stock and to take hay the following June or July and then to graze the aftermath with sheep; in this way it is sometimes possible to avoid putting cattle on the land for a period of over twelve months and, in some cases, for nearly eighteen months.

The internal parasites produce a more difficult problem because it is known that many kinds are always present in certain pastures and that mismanagement may easily allow them to assume serious proportions. Heavy grazing with one class of stock may be sufficient to infect seriously a pasture with so many parasites that trouble may ensue for years to come. It must be emphasized that young stock suffer more from parasites than do mature stock which often show no visible ill-effects; as a general rule young stock are the indicators of the presence of parasites on pastures. Where it is practicable young stock should graze a pasture before the mature stock rather than in the reverse order.

Poultry thrive well on pasture but they must be provided with fresh grass constantly and provided this is done no trouble will ensue. All pigs, except those being fattened for bacon or pork, thrive better out of doors than when housed in summer in this country, and in many districts are more healthy out of doors throughout the whole year. Whenever little pigs are reared on grass, provided the grass is free from internal parasites, they make better live weight gains than if they had been housed, and the scouring, that is so prevalent amongst little pigs suckled on concrete floors, is avoided. Pigs need fresh grass at frequent intervals and for safety no field should be used entirely for pigs for more than six months; it is doubtful whether any pigs should be permitted on that field again for a period of 18 to 24 months. The most common parasite found on pasture and which attacks cattle is the one which produces husk (Dictyocaulus viviparus). This parasite is found in low-lying, wet pastures and its eradication is exceedingly difficult; in practice, since young stock are more susceptible, only more mature cattle should graze infected pastures. It is commonly stated that "the worst enemy of the sheep is another sheep"; no doubt, on account of parasites, this statement originated. A greater variety of internal parasites are found in the sheep than in any other live-

stock on the farm. Very heavy and continuous grazing with sheep usually leads to parasite troubles except where the Romney Marsh sheep are found; it seems that this breed has developed an immunity to parasites through years of heavy sheep grazing, both on the farms of Romney Marsh, and in the orchards of Kent. No other breed or cross of sheep must ever be made to graze a field so heavily that they must eat near sheep droppings because of the risk of parasite troubles. Ewes and lambs thrive better if they can remain grazing one field, or grassland area, for several weeks (usually not more than one month) rather than if they are moved to a fresh field every few days. When cattle are mixed with sheep for grazing not only is the grass itself more efficiently utilized but the presence of cattle reduces the risks of parasite troubles in sheep. As a means of combating internal parasites and diseases it is common practice to graze stock in a sequence, for the pests and diseases found in one class of livestock are not, in general, found in others. There are no recognized systems but the following combinations are often found, sheep in poultry runs, sheep in pig runs, poultry rearing on ordinary pasture, portable pig houses on pasture, cattle, sheep and horses either mixed or grazing in rotation.

As a means of providing healthy grazing for stock, and especially for young stock, mention may be made of the system of alternate husbandry that is to be found in some districts of the British Isles. Alternate husbandry consists of cropping for several years, often for 3 to 6 years, with arable land crops, seeding down a grass mixture with corn as a nurse crop, and then, after a period of 3 to 6 years as grassland, ploughing up again and so on. This alternation from grass to arable land often involves expense of fencing and watering for the grazing period, but experience shows that, on many soil types and in many different districts, the system is worth while. During the period under grassland it is observed that the young stock thrive better than they do on permanent pasture. The possible reasons for this are (1) that the herbage is more nutritious from the new species than from those species found on old pasture, (2) that the grassland is free from parasites and diseases, (3) that there are few, if any, undesirable weeds in the new pasture. These advantages persist throughout the few years of the grass phase of the rotation provided care is exercised with the grazing. If by any chance, during the grazing period, the field has been infected with disease, or parasites, the period under the plough will be sufficiently long for most of these diseases and pests to disappear. Great care is necessary with

the management of the grazing on this system for young grasses and clovers are liable to cause scouring in stock. Also newly laid down pasture does not possess a turf or sward and often much bare ground may be visible; this may often lead to a poached surface if stock remain on these pastures in periods of wet weather during the first year of a four year ley. It may be necessary, therefore, to move the stock from the new ley to the old pasture whenever there are wet periods during the grazing season.

If fields are badly grazed diseases and parasites persist much longer in the sheltered conditions provided by the grass. Sunny, airy and dry states are most unfavourable for the persistence of diseases and pests. Short grass allows sun and air to penetrate the sward and make it healthier for stock.

The food value of pasture is not only variable from one pasture to another but varies on the same field throughout a season and from one season to another. On all pastures the grass is most nutritious in early spring, at which time the grass is a laxative food and care must be taken in grazing to prevent stock from scouring excessively and also from becoming "blown." Even if grazing is well managed, grass deteriorates in food value as the season advances. The rate of deterioration depends on the rainfall. Drought leads to poor growth, an increase in the dry matter content of the grass and clovers and a rapid reduction in the stock carrying capacity of a pasture. A heavy rain during a period of drought may provide a sudden, vigorous growth of grass; such grass will contain a high water content and will have a laxative effect on the stock eating it. A wet season produces large quantities of succulent grass which makes the stock eating it scour. It is a curious fact, nevertheless quite true, that livestock never seem to thrive well when the grass is very laxative and actually they make the best growth when the grass is inclined to be scarce, provided there is no real shortage. As a means of demonstrating the effect of season on the productivity of a pasture the principle of feeding the dairy cows in the Cambridge University Farm may be cited:

"In late April the grass provides maintenance and complete nutrifor 2½ gallons of milk and proteins for a further 1½ gallons."

"By July the grass provides maintenance and complete nutrients for 1 gallon of milk."

"By August the grass may provide at most maintenance only."

In a very dry season, when no green-soiling crops are available it is sometimes necessary to feed winter maintenance ration of hay and dried sugar-beet pulp in August because grass is so scarce. Even in

a good season it is very rare for the grass to be sufficiently good for maintenance purposes as late as October in the year.

During the winter the feeding value of grassland is low because very little growth takes place then; it is young grass that contains the high food value. At such times the grassland is more of an exercising ground than a feeding ground if the grassland has been properly managed throughout the grazing season.

In most districts a certain amount of hay is made from grassland, sometimes the same fields being set aside for hay-making annually (these are known as meadows) whilst at other times hay is taken on the various grass fields of the farm in rotation; thus hay may be made from each field once every three years. In general the annual removal of hay from a field results in producing a field of poor botanical composition through loss of the more valuable grasses, it being especially low in clover percentage, the resulting hay being of poor food value. On the other hand when hay is taken from a field once every three or four years the sward may contain a high percentage of clover, and hay of excellent food value may be obtained. Although mention has been made of the botanical composition of the pasture from which the hay is made there are several other factors that are very much more important in influencing the value of the hay produced, such as age at cutting, weather for hay-making, and the storage of the hay in the stack.

Without a doubt many farmers still make the mistake of cutting grass for hay too late in the season. The effect of this late cutting is to obtain a high yield of dry matter per acre, but very frequently the food value obtained per acre is much less than if the grass had been cut at an earlier stage of development. Early cutting gives a smaller total yield per acre, but the hay obtained may be of much higher nutritive value than if the grass is cut late in development. If a crop is cut late the nutrients have passed from the leaves and stems into the seeds, and frequently these seeds are shed during the process of hay-making. In such cases the resulting hay produced may be "straw" because the seed has been threshed out whilst cutting and making the hay. As a general rule, if good quality hay is required, the grass should be cut when most of the species have reached the flowering stage, and very definitely before any quantity of seed has been set.

The weather experienced during hay-making greatly influences the quality of hay produced. The best hay is made in a dry period and while there are no very heavy dews. On the other hand very hot weather may also be a slight disadvantage because then the leaves of

grasses and clovers may be dried so completely that as soon as the crop is turned, carried and stacked many leaves crumble to powder, fall to the ground and are lost. These leaves and tender parts of the plant are high in food value and loss of leaf lowers the food value of the hay; as a means of reducing loss of leaf during a hot dry period the grass is sometimes piled into cocks and left till ready for carting. During a showery period the cut grass, or swath, is moved frequently to facilitate drying; such frequent movement leads to much loss and wastage of the leafy parts of the plant. Heavy rains over prolonged wet periods may ruin a hay crop. In the first place the readily available nutrients are washed out of the grass, secondly the hay obtained may be badly splashed with mud and by the time it is fed to stock it is very dusty (from mud and also from mould spores which may be rather numerous), thirdly the hay is of bad colour and looks very unappetizing, finally it is very unpalatable and is only fit for feeding to store cattle, or in the worst cases, is only satisfactory for litter. In districts where the rainfall is heavy the hay is frequently dried on wired fences, on tripods or in large cocks in the field to increase the speed of drying and to reduce the possibility of soil being splashed on the grass.

It is commonly stated that more hay is spoilt in a good hay-making season than in a bad one; this is because in a good season the hay is put into the stack before it is sufficiently dry. In this country, there is always the feeling amongst farmers that good weather will not last and that the hay must be put under cover as quickly as possible. If hay is stacked before it has lost sufficient sap from the stems, especially from the nodes, heat is developed in the stack and in extreme cases the stack may burst into flames. When a stack has been heated, but not sufficiently to ignite, the hay is fit for feeding to stock, but the centre of the stack may frequently be brown in colour and in extreme cases may be a mass of black charcoal. Such charcoal has a low feeding value, and any hay that either looks brown from heat, or smells heated or burnt, has a lower food value than hay that has been stored properly. When heat is produced in a stack nutrients are burnt up and that is why the feeding value is reduced. On the other hand some farmers prefer the hay to have a slight smell of heating because experience shows that such hay is exceedingly palatable to stock, although the slight heating will have reduced the food value of the hay. Sometimes salt is added at the time of stacking to increase palatability of the resulting hay.

It is also possible to stack hay when it is wet from rain or dew; then it does not become heated in the same way that hay containing

sap does. Usually such hay is mouldy when it is cut from the stack and when it is moved in forkfuls clouds of dust (actually moulds) will surge from the hay. The feeding value of mouldy hay is not only low but it is a dangerous food, since many kinds of moulds are poisonous to farm animals.

Very good meadow hay is an excellent food and is equal in nutritive value to the very best hay that can be produced from arable land. Such first-class hay is an excellent food for dairy cows and they will usually milk freely on a ration containing it. Calves—under 3 months of age—thrive better on good meadow hay than on any other kind of hay. Good meadow hay can be fed to any farm animal but the above two classes of stock will give the best returns for the best quality. On the other hand very poor meadow hay that has been cut after the grasses have seeded and that has been badly weathered, may be so unpalatable that even hungry store cattle will not eat it, and such hay is only suitable for bedding. Some of the poor, but edible, meadow hay may have a food value approximately equal to the better straws; these low quality hays may be given in large quantities to housed hungry store cattle over the age of one year.

During the last few years grass drying has become the vogue in some districts, and there can be no doubt that, if the right grass species have been cut when there has not been more than a month's vigorous growth of grass, with the present drying machines available, a first-class food can be produced which is equal in food value to some of the concentrated foods. Only the young dried grass can have a high nutritive value. On the other hand many enthusiastic farmers who have been drying grass have been cutting it too late in its development, and such grass when dry has no higher food value than good hay. It seems that in some seasons most of the dried grass produced has been only first quality hay, which, at £6* a ton (this is its approximate cost when dried) is a relatively expensive food. Those pioneers who have dried grass in a practical way find it is very difficult in normal times to reduce costs below the above figure per ton. They also find that the output from some driers is so low that when grass is growing rapidly they are unable to cope with supplies, and in consequence the grass is more mature when cut than should be the case. It is obvious that the normal variations in food value from one field to another, the changes that occur from one season to another and the variations in the development of the sward when cut all result in dried grass being far from a

* This figure for drying was prior to the war of 1939

uniform product. The difficulty then arises of assessing the food value of the dried grass; that is difficult even when chemical analyses are carried out at frequent intervals during the drying campaign because the digestibility is not known for each sample. It seems that it is impossible to cope with the difficulty of variability but experience shows that good quality dried grass, i.e. grade 1 quality with over 17% crude protein, is suitable for a dairy cow in milk and to replace a concentrated mixture—4 lb. of dried grass being equivalent to 3½ lb. of a balanced mixture of concentrates. Usually dried grass is very palatable but some samples, for reasons which are difficult to understand, are unpalatable, although they have a satisfactory analysis. Autumn dried grass on account of the presence of leaves from trees, may be very unpalatable but usually spring grass is very palatable when dried. Although good quality dried grass is quite suitable for feeding as the concentrated ration for dairy cows it has other uses which seem to be more important. At the present time, on some farms both pigs and poultry are being kept intensively and are quite frequently housed, throughout the whole of their lives. Experience has shown that the use of green foods has kept such stock healthy; recently, lucerne meal has been used instead of the fresh foods with excellent results. Of late years finely ground dried grass has been tried and used in the rations of all housed pigs and of all poultry; usually only 2 to 7% is included in a ration. It is clear that if good results are obtained by using such a small percentage of lucerne meal, or grass meal, in a ration it is not because of the starch or protein content of the meal. Actually dried grass and lucerne may contain an appreciable percentage of carotene, but wilting in the field together with storage of the dried grass in the long state in bales, may easily reduce the carotene content to that of meadow hay. Animals can obtain vitamin A from carotene hence the importance of feeding it to housed stock, especially young and breeding pigs and poultry. Carotene, when fed to dairy cows, will influence the colour of the milk-fat produced; dried grass may be given to such stock during the winter feeding period as a means of improving the colour of the butter-fat in milk. In the case of poultry, it is also valuable for improving the yolk colour of eggs laid by birds kept under battery cage conditions.

The last way of conserving grass for winter feeding is by making it into silage. This practice is not very popular in this country but in some countries in Europe, e.g. Holland, grass silage has been made for many years. In some localities in that country every farmer makes clamp or stack silage from grass and some farmers

make more grass into silage than into hay. To produce a good product the grass must be cut when young and ensiled almost immediately. Three* methods of making silage are quite common,

(*a*) nothing is added to the grass, but the silo is filled intermittently to produce plenty of heat;

(*b*) the silo is filled rapidly and acids added to produce A.I.V. silage;

(*c*) the silo is filled rapidly with sugar added to produce molassed silage.

The first method produces good silage but the great heat leads to much loss of nutrients, the second method reduces the amount of wastage of nutrients but chalk has to be given to stock receiving the silage to counteract the effects of excess acid, the third method, however, produces a food safe for feeding and very little nutrients are wasted. At the present time the amount of sugar or molasses to add to the grass has not been carefully worked out, but it seems that in future this may be the most common way of making silage. Grass silage, on the Continent is given primarily to dairy cows and to a less extent to young stock. Possibly more attention might be paid to the making of grass silage in this country as a means of conserving grass at any time during the grazing season when an excess is produced. The chief times when an excess of grass is likely to occur are in the spring and autumn flushes, and possibly after a wet period in summer. The modern method of conserving grass in Holland in silos does not call for much capital outlay; only a small concrete wall for a silo (costing about £15 a silo) and all the machinery required is that used for the normal hay-making. In 1938 a combination of wire and sisal paper was put on the English market and satisfactory silos of 30 to 40 ton capacity were obtained for a cost of £10, the cost of replacing the paper annually was about £2, but of course the wire would not have such a long life as the concrete mentioned above. Subsequently the reinforced concrete silos appeared and some designs were very satisfactory but others burst when filled with silage. The most common concrete silo is the one made with reinforced pillars, between which paving stones are placed and strong steel bands run around outside the silo. A warning should be given that if wet brewers' grains or wet sugar-beet pulp or cooked potatoes are put into a silo then special reinforcement is essential owing to the way in which these foods pack tightly into the silo.

* A fourth method has just appeared in which a proprietary compound and salt are added which leads to the production of lactic acid.

VII

THE PREPARATION OF FEEDING-STUFFS FOR FARM ANIMALS

IF livestock are to make the best use of food that is given them they must digest it thoroughly; at times it may be practicable to prepare the food to facilitate digestion, but it is always essential to consider whether such preparation is worth while especially in view of the present high cost of labour. On many farms it is possible to modify the digestibility of some foods prior to feeding by treating them, but some treatments are only possible under factory conditions; in such cases it is obvious that a cash price must be paid for the service rendered. Another reason for treating foods is to make poor quality tasteless feeding-stuffs more palatable and so entice stock to eat what they would otherwise refuse; it is doubtful whether it is really worth while to make stock eat these low value foods. The preparatory treatments to be discussed here are pulping, chaffing, crushing, grinding, mixing, soaking, cooking, sprouting of grains and cubing of concentrates.

Pulping.

Before the World War of 1914–18 it was the custom to pulp roots prior to feeding them to cattle and sheep; this was done with the well-known slicing or pulping machines. Before the roots were sliced they were carefully cleaned; this cleaning was, and still is, a sound practice. After the pulping had been completed the roots were fed by themselves, or with concentrates, or with chaff added. In the latter case the pulped roots were mixed with the chaff several hours before feeding to moisten, and so to soften, the chaff, and to facilitate digestion. The real object of pulping the roots was to entice the stock to eat more roots than they would otherwise have done, but doubt is raised whether it was really wise, and economical, to make stock eat such large quantities of roots. This question often turns on the relative costs of roots and carbohydrate concentrates for fattening purposes. To take a single example, mangolds or swedes will cost 15s. to 30s. per ton by the time they are ready to feed to stock, but at least 8 tons are necessary to replace

1 ton of dried sugar-beet pulp or 1 ton of crushed oats in the concentrated ration; the sugar-beet pulp is sometimes sold at just over £4 per ton and crushed oats at between £5 and £10 per ton. From the above it is obvious that unless the mangolds are ready to feed at the lowest cost of 10s. per ton then the beet pulp is the cheaper food; on the other hand compared with oats roots will usually be the cheaper proposition. It is not uncommon to find, in Scotland, that it is still the custom to feed 112 lb. of roots to fattening cattle and to reduce the quantity of oats fed in the concentrated ration. Evidence is now available to show that roots are beneficial in the ration of dairy cows, but that the optimum daily ration for an 11- or 12-cwt cow is only 40 lb. of mangolds daily; larger amounts cannot be thoroughly utilized. In the preparation of stock for shows one is prepared to forget economics; for show animals pulped roots may be given to encourage them to eat as much as possible.

Apart from the case of fattening cattle and that of fattening crone ewes with broken mouths, it is unnecessary to consider even pulping the roots. Some farmers still think stock are likely to choke when given whole roots but this has not been the experience of the authors.

(The case for cutting up green-soiling crops for indoor feeding will be discussed under chaffing.)

Chaffing.

On many farms chaff-cutters are to be found but they are not always in working order; this is partly because chaffing is not as popular as it was, but also because it is a common practice to cut up the straw at threshing by means of a large chaff-cutter that is part of the threshing outfit.

There is no doubt that, shortly after the World War (1914–18), chaffing of straw lost a certain amount of popularity and since that time the amount of chaff that has been fed to dairy cows has been much reduced. By chaffing straw and poor quality hays, cattle, and especially dairy cows, were made to eat vast quantities of roughage which provided them with very little food value. A little thought shows this procedure to be wrong, but some farmers still continue feeding in the old-fashioned way. This mistaken procedure may be explained in this way, the process of chaffing mixes, indiscriminately, small pieces of the leaf of straw with small pieces of the stem. The leaf often has a very high feeding value but some parts of the stem have such an exceedingly low feeding value that the animal expends more energy chewing and digesting the stem than

is actually obtained from it; stock should not be forced to eat such poor food. If straw is to be given to stock it is usually far more satisfactory to give it them in the long state so that they can pick over the leafy, and more tender and nutritious parts of the straw, and discard the woody portions of the stems; these may be thrown into the yards as bedding and trodden down into farmyard manure. Whenever it is necessary to reduce feeding costs by giving straw to cattle it is unquestionably more satisfactory to give them long straw than to give it them chaffed. In any season when hay is dear it is claimed that the use of chaffed hay is worth while, because little wastage occurs when it is fed short in mangers. Long hay fed in racks or cribs is often wasted but it is quite easy to use fittings in the cribs or racks to prevent wastage.

For horses the situation is rather different because chaff is an essential in their rations for dietetic reasons. In this case the chaff is mixed with the concentrates to make horses chew their concentrates thoroughly since they are inclined to bolt them. Chaff should always be mixed with the concentrates for horses except when a food such as bran mash is being given to a sick, or to a foaling, animal. It is not necessary to give more than 4 lb. of chaff with the concentrates but it is foolish to give a poor quality chaff; in practice a good oat chaff or a chaffed second quality hay should be given. Whenever horses are housed in the winter and they are doing light work it is possible to economize in feeding by using additional straw in the ration; then it is used to replace hay, and possibly concentrates, and should be given "long" as for cattle.

It is often desirable to give some roughage to sheep and hay or straw may be used for this purpose, but unless sheep are being fattened, or the food is for crones that have lost their teeth, the long fodder is preferable to chaff. For fattening sheep and crone ewes chaff is better than long material, but hay is to be preferred to straw for this purpose.

Where it is the custom to feed kales or maize (green-soiling crops) as green food to housed cattle much wastage will arise, if these foods are given to the stock whole, owing to the foods being dropped on to the ground and thus trodden into the bedding. To reduce such wastage it is desirable to cut up these green-soiling crops into lengths of stem or leaf of 4 to 6 inches, this is done by a modified chaff-cutter which works on the same principle as the ordinary chaff-cutter for straw; except that in this case the lengths of stem produced are much longer than when straw chaff is made. This policy of cutting up green-soiling crops for housed stock of all kinds can-

not be too strongly advocated as a means of preventing wastage of food.

Crushing and Grinding.

Some animals are ravenous feeders and eat concentrated foods at such a speed that the foods, especially whole grains, are not chewed and pass through them undigested and may be passed out in the fæces; these grains may be discerned readily by the naked eye. Whenever this has happened not only has the food been wasted itself but the animal has wasted a certain amount of digestive juices and muscular energy, the latter being used in propelling the food from the mouth through the digestive tract and finally expelling it from the anus. Whenever it is likely that food may be "bolted" it is desirable to treat it so that it may be acted upon by the digestive juices even if it is not masticated properly. It is just possible with young animals that grains are too large for them to be "bolted" and they are forced to chew them properly before swallowing, in such cases it is a waste to prepare the foods. Calves up to 6 months of age chew whole grain thoroughly; not only is it a waste to grind or crush grain for them, but experimental work shows that calves thrive better, and seem to prefer, the whole grain to any prepared form. Sows may utilize whole grain quite well, but for them it should be soaked. Another advantage of crushing or grinding grain is that any weed seeds that may be present will be so damaged that they will not germinate even if they are passed out of the animal in the dung. As a means of guarding against waste by the "bolting" of foods crushing or cracking is often carried out; crushing is done by passing the dry grain between rollers and the grain is either flattened or shattered into small pieces. The kinds of cereals that are grown in this country are crushed, or rolled, but beans, peas and maize are cracked or kibbled (which is a term used when maize is cracked).

Whenever these prepared foods (crushed and cracked) are available they should be included in the concentrated rations for calves over six months of age, for all store cattle, fattening cattle and dairy cows, for both sheep and horses of all ages, irrespective of the object for which they are being kept. On many farms mills are kept for crushing or rolling the grain but if the machinery is not available it is possible to buy the foods already prepared. The cost of rolling, or crushing, a cereal is low and should not exceed 10s. per ton and may frequently be half that figure; there can be no doubt that even if the cost is 15s. per ton this treatment is worth while.

Grain foods are invariably fed in a "cut" or cracked form to chicks up to the age of 8 weeks, after that period oats or wheat are fed whole but maize is always fed in a cracked or kibbled state.

It is the custom to grind foods for feeding to pigs and poultry because they both have small and weak digestive systems and every attempt must be made to facilitate digestion for them. For other farm animals grinding of foods is unusual in this country except for calf feeding, when gruels are being made; but in other countries, especially in the United States of America, foods are ground for all farm animals, in which condition they seem to be very much relished. In this country, perhaps as the result of a long-standing custom, cattle, especially dairy cows that receive large quantities of concentrates, seem to find ground foods unpalatable because they are pasty in the mouth.

In the past all meals were ground by mills with stone rollers, but the more modern mills have steel rollers for grinding; opinion is still prevalent that better meal is obtained from the stone rollers than from the metal ones. It seems difficult to accept the fact that the stone rollers produce a better food, for the only differences that can exist are additions of particules of the stone rollers to the meal and variations in fineness of grinding. With the advent of hammer mills it is possible to regulate the degree of fineness of grinding over a wide range. One might expect it to be impossible to grind foods too finely for pigs and poultry, but experimental work in some countries shows that grinding to the fine floury condition is wasteful for it increases costs of grinding and the resulting food is unpalatable, through either dustiness or pastiness in the mouth. On the other hand experimental evidence seems to suggest that grinding till the product is "gritty" to the touch is the ideal.

Little if any, experimental work has been done on the relative merits of foods freshly ground versus stale (though those who have visited Scotland know that porridge made from freshly ground oats is infinitely superior to English porridge); whenever storage is to be practised the meal must, of course, be stored in a dry place, and the sacks should not lean against a brick or concrete wall or stand on anything but a wooden floor. Too many sacks of meal should not be placed in a heap immediately after grinding, otherwise heating may ensue; this makes the meal sour and unpalatable and in extreme cases it may go mouldy. Although all meals call for some attention if they are to be stored none demand more skilful treatment than beans and peas, especially when they are a little moist.

At the present time a few farmers, and a number of manufacturers

are drying lucerne and young grass, and, in some cases, the dried product is being ground up finely for stock feeding. No increase in digestibility is to be derived from grinding up roughages for cattle and sheep; in fact digestion is actually impaired, sometimes, through inadequate rumination. The finely ground lucerne and dried young grass is of value, however, for mixing with meals for pigs and poultry especially when these stock are kept under housed conditions and when no green succulent food is available; in such a case the lucerne or grass meal may constitute 2 to 7% of the mixture. At the present time manufacturers of balanced foods for farm animals are using these dried products in rations for various farm livestock.

Mixing.

Most farm animals receive concentrates at some time during their lives and there is plenty of nutritional evidence to show that it is desirable to give live stock a mixture of concentrates as opposed to a single food, for most purposes. At first sight it would seem quite easy and possible to mix the concentrates by hand on a barn floor, but experience shows that such mixing is often difficult to accomplish properly. Rations that are being mixed for cattle often consist of crushed cereals and oil cakes and since the texture of these foods is variable it is obvious that a good mixture is difficult to achieve. On the other hand, from the point of view of the livestock, good mixing is essential or otherwise they may be underfed with some particular nutrient, and, what may be worse, at one feed they may receive an excess of the unpalatable part of the ration and so refuse to eat any of the so-called mixture. It is obvious that a serious attempt must be made to mix the foods properly and for this purpose a good concrete floor is essential. Each food must be sprinkled over a large flat heap, the whole ration being put in layers may be thoroughly mixed by twice turning the heap completely. Where foods of various textures are to be used it is obvious that thorough mixing is difficult on the farm, but the manufacturers of cakes for livestock can overcome the difficulty, by grinding all foods to a constant size before making them into cakes or nuts. This is only one of the advantages to be derived from the use of purchased mixed concentrates.

It is quite common practice to use finely ground feeding-stuffs for pigs and poultry feeding, such foods being much easier to mix; the difficulty in this case, however, is that often small quantities of relatively heavy minerals have to be used. Then, to ensure thorough mixing, the mineral is first mixed with one part of the ration,

this supplementary mixture is then added to the whole and turned on the floor at least twice. The importance of thorough mixing of concentrates is recognized by some practical men because mechanized means are available for the purpose. Again, the purchased proprietary mixed meals are so thoroughly mixed that there is no danger of any animal receiving an excess of any ingredient of the mixture.

It is a common practice when feeding some farm animals to mix concentrates with other parts of the rations, but in such cases mixing at feeding times is all that is required. Earlier in this chapter the mixing of chaff with concentrates for horses to prevent "bolting" of the concentrates has been mentioned. Concentrates are often mixed with silage for cattle just at the time of feeding, then the main object is convenience to reduce handling several kinds of food at a time. Farmers who pulp roots and chaff straw, mix these two foods together for 12 to 24 hours before feeding to enable the juices of the roots to soften the straw chaff.

Foods are sometimes mixed with water before feeding, but since soaking is to be discussed this subject may be more conveniently considered under that heading.

Soaking.

Foods are soaked prior to feeding for several reasons; in the first place, foods that are dry and likely to swell appreciably after consumption are often soaked before feeding to reduce risk of distention of the stomachs of the stock consuming the dry foods; secondly, soaking leads to a softening of hard tissues and thereby facilitates digestion; thirdly, the addition of water to a dusty food reduces risk of producing respiratory troubles; fourthly, moistened food is often more palatable than the same food given dry; fifthly, water added to mashes produces rations that are slightly laxative; finally with moistened food, because of its extra weight, less is wasted from mangers by wind and by animals breathing on the food. Some authorities question the value of soaking to increase digestibility and go so far as to state that it may actually impair it, but there can be no doubt that with very hard grain or kernels soaking will save the necessity of grinding and the latter is accepted as assisting in digestibility. As there is some doubt as to the value of soaking the numerous cases where it will be beneficial may be cited:

(*a*) When feeding dried sugar-beet pulp either as a succulent, as part of the maintenance ration, or as a concentrate when it provides a considerable proportion of the ration.

(*b*) When dried products such as potato flour or flakes are being fed to pigs.

(*c*) When bran is being given as a mash to any stock as a mildly laxative food.

(*d*) When whole maize and whole beans are being prepared for throwing to pregnant sows on pasture.

(*e*) When wet dairy products are available in large quantities for feeding to pigs, calves and poultry, meals are often mixed with these by-products.

(*f*) When pigs, especially young pigs, develop a cough when receiving dusty or mealy rations, the latter should be moistened.

(*g*) When stock are being pushed for fattening or for showing soaked foods are given because of their greater palatability (e.g. show cattle and pigs).

(*h*) When it is cold weather a warm mash for laying birds stimulates egg production.

It must be emphasized that if soaking is not arranged for outside the animal body, and dry foods are given, the stock must be given a good supply of water; they may drink at will so that the soaking may take place within the animal body. Whenever this is practicable it is to be advocated since it reduces the labour of taking water, in the food, to the stock. For pigs, however, a recent modification, which saves labour and produces the advantages of moist feeding with the minimum of labour, is to place the meal in troughs (in a Danish piggery) and there, by means of a hose-pipe, water is added to the ration before feeding; this is, without a doubt, a sound procedure.

Making plenty of water available and feeding dry foods has several advantages over soaking, in addition to the labour question mentioned above; the troughs are kept sweet and not fouled by stale food, the food is given fresh and the risk of fermentation in the stomachs of stock, especially of horses, which may arise from the giving of stale food, is avoided.

Wet-mash Feeding.

In the case of poultry, wet-mash feeding is often preferred to dry-mash feeding, its advocates claiming that such a system gives better results. Since, however, it has been proved by experiment that dry-mash feeding yields just as good results as wet-mash feeding provided the mash is a palatable one, the reasons underlying the occasional superiority of wet-mash feeding may be briefly discussed. In the preparation of wet mash, only sufficient water is added to produce a crumbly wet mash, which when grasped in the hand can

be moulded into a firm lump but which readily breaks apart when thrown to the ground. Poultry have but poorly developed senses of taste and smell, the touch and sight senses are, however, highly developed. Foods which possess sharp angular surfaces, or which become pasty when wetted, or which readily absorb water and swell on being moistened, are consequently disliked by poultry if given in a dry state. Foods of a dusty character are also disliked, owing to the clogging of the nostrils and mouth passages that may occur if such foods are given in the dry state. Foods possessing shiny surfaces or which are light in colour are preferred to those which are dark in colour or non-shiny. Where foods are unpalatable owing to their possessing sharp angular surfaces, the difficulty may be overcome by clipping or grinding, in all other cases the difficulty can be overcome by feeding as wet mash. In the case of dusty foods, the difficulty can be overcome by pelleting the foods. Indeed, the superiority of wet-mash feeding over dry-mash feeding may be traced in the majority of cases to the fact that the mash when fed dry is unpalatable owing to one or more of the reasons already mentioned. Wet-mash feeding is also indicated in cases where the poultry flock is suffering from coccidiosis, since the food hopper is an important factor in the spread of this disease; consequently dry-mash feeding tends to encourage its continuance.

Cooking.

Under the heading of cooking may be included steaming, which produces the same effect as cooking, and also passing between hot rollers, e.g. as with the preparation of flaked maize. Taking the last case first, it should be emphasized that this processing of maize calls for factory equipment; this treatment cannot be carried out on the farm by a farmer himself. Flaked maize (cooked is implied) is very popular in this country for feeding to various livestock. It is more digestible than maize in its original state. The cost of this treatment is not very high for the price per unit of Starch Equivalent is the same for flaked maize as for maize meal and only 5% higher than for the original grain; this is a very small price to pay for the greater digestibility and the more palatable food. Flaked maize is usually given to either young stock, sheep, cattle, horses, pigs and poultry or to the older heavy producing stock, e.g. to cows or to fattening stock, especially to cattle and to sheep. Another case may be mentioned, e.g. some farmers still prefer gruel for calf feeding; this involves cooking of the calf meals, this question will, however, be discussed in the chapter which includes calf rearing.

There is some evidence that the cooking of some of the cakes and meals, which is occasioned by the extraction of oil from seeds by the expeller process, increases digestibility of the residue; this is especially so in the case of soya-bean meal required for feeding to pigs. There is no evidence for cooking any foods especially for any stock other than for the pig, except with maize mentioned above. Even for the pig cooking of foods may, in general, according to accurate experiments, reduce their digestibility by as much as 10%.

There are two kinds of foods for pigs that, without a doubt, pay for cooking and they are potatoes and hotel swill. The former case is generally recognized from two points of view, namely that cooked potatoes are more digestible than un-cooked ones, and secondly the cooked potatoes are a much safer food for they will not cause digestive disturbances to the same extent as will un-cooked potatoes. It is also worth pointing out that cooked potatoes can be used quite easily with meal and so may be consumed more completely than if the meal and raw potatoes were fed separately. The importance of cooking swill lies in another direction, a legal one, for by law all such swill must be boiled for 30 minutes before being fed to pigs; this is the outcome of diseases having been carried to farm live stock through the medium of hotel swill, especially through meat scraps and bones.

Sprouting grains.

During the last few years a new process has been placed on the English market whereby in from 8 to 10 days grain, specially treated, and grown in a special cabinet, may make 8 to 10 inches of growth. This treatment alters the nature of the food for instead of the original grain a green, succulent food is available, but it is impossible for the change of form to increase the food value of the original grain. Experience shows that the best grain to use for sprouting is maize because of the large food reserve in the seed, but a difficulty lies in the fact that low germination of the grain is frequently experienced; there is also the risk of moulds being produced. The sprouting of the grain is induced by heat, water, nutrient solution, and darkness for most of the time that sprouting is taking place; it is difficult to conceive that this process can increase the nutrients available, for one knows that when seeds germinate a certain amount of plant food is burnt up from the grain. Actual experimental evidence shows that this is the case and actually there may be a loss of 25% of the dry matter of the grain. Whether the loss is worth while in converting the grain into a succulent food is a question that only

individuals can decide for themselves. The resulting product may be useful in dry districts or in places where succulent foods are difficult to grow, or cannot be grown; for ordinary farmers in this country it is a moot point as to whether it is worth while.

In England the sprouted maize used experimentally in the dairy ration proved no better than any other succulent food for such stock. In Scotland the sprouted maize has been compared with roots for fattening cattle and there the opinion was very much in favour of the sprouted maize, and the suggestion was made that stock receiving even very small quantities of the sprouted grain carried a characteristic but better coat than those receiving roots. It was suggested that even a very small quantity produced this beneficial effect and that some nutrient other than starch equivalent or protein equivalent must have been responsible.

It is also well known that sprouted grain may stimulate reproduction and the feeding "chitted" oats to non-breeding cattle and horses induced them to breed provided their reproductive organs were otherwise normal. The possible value of feeding the sprouted oats to such stock may lie in the fact that vitamin B_2 is made available which is supposed to reduce sterility. No elaborate apparatus is necessary, since the grain is merely sprouted in a tub or similar receptacle and fed wet to stock when the sprouts are about an inch long.

In general it may be stated, with the present knowledge, that sprouting of grain for stock feeding is not worth while for ordinary farm stock.

Cubing of Concentrates.

Since the World War (1914–18) an increased tendency on the part of farmers to buy concentrates from manufacturers mixed ready for feeding has been noted; in many cases the foods are not only mixed but they may be cubed. The manufacturers apparently do not charge high prices for mixing and cubing and from the trade that is developing farmers seem to find cubed foods very satisfactory for livestock. Cubed foods are exceedingly palatable, for British livestock are used to eating cubes whereas the American stock are accustomed to eating mealy foods and not cubes. This palatability may be the outcome of the cubing process, but it may be in part due to the condiments added by the manufacturers of cubes, and also to the treacle that is used to bind the foods together. These cubed foods are, of course, thoroughly mixed and therefore this, of itself, may add something to their value. The cubes are relatively large and

heavy and as a result little wastage of concentrates can arise through foods being blown about by wind or by animal's breath. A further advantage is found with out-door feeding, because cubes may be scattered on the grass at feeding time for the stock whereas meals demand the use of receptacles; this not only increases time and trouble at feeding time but receptacles have to be kept clean and may have to be moved to a fresh site at frequent intervals; experience also shows there is a big "mortality" in receptacles used for concentrates on grassland. Lest any one should feel at all sceptical about throwing concentrates on grass the authors state, from personal experience, that the food is not wasted by treading into the ground but instead it is picked up cleanly by sows, sheep and cattle.

It is true to say that at the present time cubes may be purchased for feeding to almost all farm stock, including pellets for poultry; but fattening piglings, working horses, store cattle are usually given meals or crushed cereals which are quite frequently mixed on the farm.

Especial mention should be made of cubes for feeding to young horses out at grass either for their first or for their second winters. In such cases with home-made mixed rations much wastage occurs through wind and the snorting of the stock, the food, bran in particular, being blown away very easily.

At the present time the cubing process is only practicable under factory conditions for it involves grinding all foods to a certain consistency, thorough mixing, heating and moistening, cubing and finally drying again before bagging. It is difficult to conceive that this complicated procedure will become a farm operation except on large estates; thus for some years farmers may expect to have to purchase cubed foods from manufacturers.

The cubed foods have several disadvantages for as they have constant compositions and specific uses on a farm where a variety of stock are carried, a different kind of cube is needed for each class of stock; this may involve carrying an abnormally large stock of concentrates. Where mixed stock are kept, home mixing of concentrates allows for considerable flexibility of mixtures. Further if by any chance an animal goes off food, and it occasionally does, if only the balanced cubes are available it is impossible to cater for individual tastes. Balanced cubes will not mix with chaff for horses, or with meals or cereals for cattle; and if at any time the aim is to use home-grown cereals then it is often more convenient to feed a home-made mixture than to feed cereals and cubes. It should also be noted that unless cubes are especially designed for feeding

with a certain proportion of cereals then the feeding of cereals with them will upset the balance.

These disadvantages are, however, relatively slight compared with the advantages, especially convenience of feeding, and statistics show that the feeding of cubes is extending rapidly in this country.

VIII

THE GENERAL PRINCIPLES UNDERLYING THE FEEDING OF FARM ANIMALS

The Practical Aspect of Balancing Rations.

WHEN the analyses of the common feeding-stuffs are known, and the theoretical requirements of the farm animals are understood, many other factors must be considered before the scientific feeding of farm animals can be carried out and before stock may thrive on their newly calculated rations. It is quite possible for a person with no practical knowledge to produce rations that may provide all the necessary nutrients, but which the stock will not eat because of their unpalatability. As a general rule the stock that are most likely to be fastidious about their food are those receiving relatively large quantities of concentrates, e.g. fattening stock, high-yielding cows, racehorses, very young stock and any stock being prepared for showing. The foods that are usually very palatable are the succulents and it is very rare that stock refuse them provided they are sound and in a fit state for feeding, i.e. sufficiently mature. Whenever livestock are receiving relatively large quantities of concentrated foods the use of succulents as part of the maintenance ration may assist the palatability to such a degree that stock may remain "on feed." During the summer housed stock may frequently go "off feed," but the use of green-soiling crops will, to a large degree, reduce the frequency of its occurrence. Most foods containing a high oil content are very palatable but there are exceptions, e.g. some grades of fish meal and sometimes rice meal. Any food that contains sugar is very palatable, e.g. sugar-beet, locust beans and molasses. The unpalatable foods are often the fibrous concentrates, e.g. the undecorticated cakes and poor quality grain. Generally stock will not relish new foods they receive for the first time, and whenever a fresh food is introduced into a ration, or if a change is made in the proportion of the constituents in a ration, it may be necessary to introduce the new ration gradually to prevent the stock from going "off feed." Sometimes it may take a fortnight before the new food is being supplied in the requisite

amount daily. The mere state of division of the ingredients in a ration may influence its palatability, as also may the class of stock receiving it, e.g. finely ground foods for cows, sheep and horses are unpalatable yet finely ground foods are generally very suitable for pigs and poultry. For cattle crushed foods are more palatable than ground foods; if a ration is given which contains too high a proportion of meal it may be necessary to add such foods as flaked maize, bran, crushed oats or even dried sugar-beet pulp before stock will eat it. There seems to be some evidence that these flaky foods are able to assist in the mechanism of digestion in some way which is not fully understood, whereas the meals tend to retard digestion. It has also been observed that when stock are given a ration that is too mealy, i.e. in a bad mechanical condition they may develop strange appetites and chew queer things, e.g. sacks, clothes, etc. If the ration is in a good mechanical condition experience has demonstrated that stock receiving the ration will have excellent appetites, better than if they had been given a mealy ration.

Bran has a good mechanical action when given to all stock; this is not entirely because of its laxative action but because it seems to increase the rate of digestion. This leads to a consideration of the effects of the different foods on the bowels. The ingredients which make foods laxative are a little obscure, in some cases oily foods lubricate the digestive tract, as might be expected, bran leads to keeping the contents of the intestines, especially the lower intestine, reasonably liquid; succulent foods work in a similar manner, by making the food rather liquid they increase peristalsis which, in turn, leads to a rapid evacuation of indigestible material. Foods are usually laxative if they satisfy one or more of the following conditions.

1. Contain a high percentage of water.
2. Have a high percentage of protein, and especially if the food is immature and the amide content is high.
3. Contain a high percentage of oil.
4. Contain a low percentage of fibre.
5. Are fed in a frozen condition.
6. Have gone mouldy.
7. Contain poisons.

From the above it will be understood why young grass is so laxative as it satisfies three of the conditions in the list. Most of the oil cakes are laxative except when they contain a high fibre content and in that event they have a hardening effect on the excreta. A ration should have just the right effect on the bowels, for both laxative or

costive actions are bad and lead to poor food utilization. When a food is too laxative it passes out through the animal so rapidly that it is not properly digested, nutrients are not absorbed, and in consequence stock do not thrive. If on the other hand the ration is costive then the food, and especially the waste products remain in the system for too long a time; poisons may be absorbed into the system, with the results that the stock are unthrifty and look unhealthy in their coats. The ration should be slightly laxative rather than slightly costive for housed stock. It is essential for the student to know the consistency of the normal dung of the ordinary farm animals. Here it might be mentioned, however, that the feeding is not always responsible for the condition of the dung, for some diseases may lead to scouring, also the mere handling of nervous cattle may make them scour for a short time. Sometimes the causes of scouring may be a little obscure but with cattle a cause which may be responsible, but yet which may be overlooked, is hay; in such cases it is difficult to decide why a particular lot of hay is laxative but experience shows it may be the case. Sometimes botanical composition may account for the action of hay on the bowels, at other times, possibly the degree of heating that has taken place in the stack may cause scouring. Such a case may be corrected quite easily by changing to another kind of hay or by modifying the concentrated ration to include more undecorticated cake, especially the cotton cake. When grass is very young, luscious, and therefore likely to cause scouring when grazed by the farm animals, several measures may be necessary to prevent this, namely by giving the animals a feed of hay known to be binding, by giving undecorticated cotton cake, or by restricting the time of grazing to an hour or two when stock are first turned on to the very succulent pasture. At times the dung may be hard and solid; this is particularly undesirable in the case of females about to give birth to young. There are various ways of correcting this condition but the most satisfactory way is by feeding laxative foods, e.g. succulents or bran mashes.

Whenever stock are housed a mixed diet containing a variety of foods is usually more satisfactory than a very simple diet. In the first place a mixture may be necessary to provide the requisite amounts of starch and proteins, secondly it may be desirable to mix palatable with unpalatable foods, thirdly it may be required to mix foods to produce the right effect on the bowels. There are, however, two more important reasons for giving mixtures and one is to make it easy to make slight changes in the ration as food-stuffs are used up, become more expensive, and so must be replaced by cheaper foods; the

other is to provide, by a hit and miss method, all the various amino-acids essential for maintenance, growth and production (production may include milk, fœtus, growth, wool and work). The situation regarding amino-acids has not been fully studied by the scientists. At the present time it is known that certain amino-acids are essential for livestock but the quantities of each required by the various farm animals and at different ages, together with the amounts of the amino-acids present in all the common feeding-stuffs, are not available. In the meantime, till this additional information is available, a mixed ration is recommended. This question of amino-acids does not arise with grazing stock for grass is such a mixed diet, consisting of so many different species of grasses, clovers and weeds and at differing stages of growth, that the essential acids are usually supplied.

It is perhaps hardly necessary to repeat that the fowl and the pig each have small digestive tracts whereas the stock normally found on a farm have large digestive tracts. These stock, with large digestive tracts, horses, sheep and cattle must have a large supply of bulky food to fill their respective tracts to give them a "satisfied" feeling. These animals are given bulky foods consisting of hay, straw, roots and grass; if they do not receive sufficient foods of this type they may become very unthrifty although they may be receiving, theoretically, an adequate supply of protein and carbohydrates. In extreme cases housed stock will eat bedding and finally any woodwork that may be used in making box or stall partitions. Wood has a low feeding value but it may satisfy an animal's craving for fibre. On the other hand there is a limit to the amount of bulk that an animal can consume; at times it may be unable to eat all the food it is offered, merely because its digestive tract is too small. The giving of excessively bulky rations to dairy cows, may result in a fall in production, to young stock may lead to stunting, and to fattening stock may arrest the fattening process. The bulk of a ration may mean the amount of fibre that it contains; other workers take a wider view and consider bulk to represent the space the food occupies in the animal's body. Frequently the space occupied in the animal's body is assumed to be proportional to the dry matter of the food. If one stops to think for a moment it is obvious there are several fallacies in this assumption; for speed of digestion, or rate of passage through the animal, must influence bulk, as also will the size to which the foods swell within the animal body when moistened by saliva, etc. It is quite well known that some foods swell more than others of the same dry-matter content. Thus, the method of assessing the bulk of a ration by merely determining the

dry-matter content can only serve as a rough indicator that the right amount of ration is being fed. As a general rule very young animals cannot eat much bulky food because their digestive tracts are small and under-developed; if they are forced to eat large quantities of bulky food, in their youth, the result may be that they develop large abdomens which remain large; such stock are described as being "pot-bellied." For store stock (except pigs) bulky food is very desirable to develop the digestive tract fully, so that in later life these animals may be able to cope with large rations. This is most important of all in the case of heifers being reared for the dairy herd; they must have good and efficient digestive systems. For mature stock bulk must be carefully watched because large quantities of concentrates are often fed to milk-producing cows or to fattening cattle. Bulk is usually modified by altering the amount of roughages fed, which, in the case of store stock, may be straws and poor quality hays; for young stock, or for breeding and high-producing stock, good quality hays will be used. In extreme cases, for store stock, treacle or salt may be added to poor quality hay or straw to entice them to eat the bulky part of the ration. It is an interesting fact that whenever there is a spell of very cold weather, in winter, stock will usually quite suddenly eat more roughages than usual, in the form of hay or straw. To allow for differences in individuals and also for weather it is quite a good practice, with stock housed in yards, to keep some good quality straw always before them so that they may eat it whenever they wish to do so.

The Stockman as a Factor in successful Feeding.

It is a well-known fact that some men are born stock-feeders whilst others given the same foods never seem to have the same "luck" with the stock they feed. Several factors may account for the difference observed between stockmen, such as, frequency and order of feeding, regularity, cleanliness, attention to such details as the provision of adequate trough room for all to feed at once, feeding receptacles and attention to sick animals. Some stockmen move quietly amongst their stock and rarely, if ever, frighten or disturb them.

Taking these points individually the first is frequency of feeding; here success must depend mainly on the age of the stock. It is hardly necessary to point out that stock suckling their own dams usually thrive well, better than young stock of the same age receiving an equivalent quantity of milk from a bucket; there may be several reasons for this, but one which cannot be overlooked is that when suckling is taking place the progeny can usually have frequent small

feeds, i.e. "a little and often." Thus hand-reared stock and newly weaned stock should be fed as frequently as is practicable; this is usually three times a day. As stock recover from the shock of weaning they may be fed twice daily. With high-yielding dairy cows that are being milked more frequently than twice daily it is usual to feed at each milking time; over-enthusiastic milkers may feed between each milking but in such cases the cow receives too little rest from feeding. When stock are being fattened, especially for fat stock shows, a policy of "a little food and often" may be adopted to increase food consumption, thus stock may be fed as frequently as five or six times a day. No farm animals should be fed less frequently than twice daily, unless very small quantities of concentrates are fed, then the latter will be given at one feed but roots and succulents at two feeds. The normal order of feeding is to give concentrates before giving the roughages, or succulent foods, to ensure that the concentrates are consumed and that diminished appetite is reflected in the quantity of bulky foods consumed. In general, when stock are fed thrice daily the concentrates and roots are given in equal quantities in good time in the morning, at midday and then late in the afternoon; usually a quarter of the day's roughages is given in the morning, a quarter at midday and the remaining half late in the afternoon as a "night cap," in all cases the roughages being given after the other foods. With stock on pasture receiving relatively small rations of concentrates daily, because of the labour of visiting them frequently, they are usually fed just once a day.

All feeding of stock must be carried out with clockwork precision and according to a strict time-table. Stock become accustomed to a routine procedure and deviations from that routine upset them. It is common knowledge that stock know the time at which they eat with a fair degree of accuracy; they may be in their places ready for feeding at a stated time, but if feeding is delayed they usually become restless and may even voice their objections to tardy feeding. Such uneasiness must lead to a wastage in body flesh and, even if it is only a small amount, it may be quite serious if a number of animals are involved and on a number of different days. Variations in time should therefore be avoided at all costs. Equally serious are variations in quantities of food from feed to feed unless more food is given at a constant time each day. Some stockmen are very careless where quantities are concerned and may under-feed sometimes and over-feed at others and so put the stock "off feed"; that may easily check normal growth and fattening. Another source of trouble in this connection may frequently be bad management which involves

running short of a ration or of some ingredient for a ration. In either case the stock may receive little or no ration or else a suddenly modified ration; this checks live-weight gains. If, at any time, milk is fed to young stock there is always the chance that souring may take place, especially when skim milk is being used carelessly. Experience shows that giving fresh milk at one feed and sour milk at another leads to digestive disturbances, but if it is arranged to feed consistently either fresh or sour milk no difficulty will ensue.

Mention of milk immediately brings to mind the importance of cleaning utensils into which the milk or the wet-milk products are put for feeding to farm animals. Troughs and buckets must be washed out frequently otherwise they may become foul with soured deposits. Milk is not the only food that goes sour for frequently concentrates, when fed in troughs, are moistened by animals' saliva and accumulate in corners and crevices of troughs. Such stale food may easily put stock off their food; this is particularly the case with young stock, with fattening stock and with high-yielding dairy cows. When roots are given in mangers stale food may remain, and wherever silage is fed in wooden mangers juices may sink into the wood, and the odour may have serious effects on milk exposed in the vicinity. Silage is very potent and mangers where it is used in a ration should be thoroughly cleaned at frequent intervals. The roughages also call for a little attention for hays and straws that have been before stock for some time (especially if stock have dribbled over them) should be removed and a fresh supply put in their places; this, if omitted, is most likely to lead to trouble with young, fattening and sick animals.

To reduce costs stock should be housed and fed in large groups. Amongst a group of stock there are always some that dominate the others whilst some are underlings thus, in general, groups should not exceed about a dozen head of stock. When feeding a group of animals the bullies may prevent the others from feeding, but if there is abundant trough room this is not usually serious for although the stock may not settle well at feeding all will have an opportunity of obtaining some food. It is usually the concentrates that give the most trouble and there must be enough room for all that are housed together to feed at once, but when hay, roots and straw are fed, the trough room is not so important because those roughages are left before the stock for some time. The mere provision of space for feeding may not be enough for sometimes one animal may not be permitted to feed; this is likely to arise when a fresh animal is added to a yard or when an animal has been sick,

isolated from the rest, and then is returned to its former yard. In such cases it may be necessary for a stockman to stand by, when concentrates are being fed, to see that the weakling receives its proper ration; after a few days usually the weakling will be permitted to feed. Sometimes, however, a group of stock so much resent the arrival of a stranger that they refuse to allow it to feed at all from their mangers; this difficulty may be overcome by providing another trough or manger for the newcomer. In order to deceive pigs when others are added it is by no means an uncommon practice to oil all the pigs so that the stranger or strangers cannot be detected by smelling; this reduces the incidence of fighting.

No discussion of feeding can be complete if no mention is made of the receptacles into which food is put. When stock are housed the roughages are frequently put into racks; this is quite a good system from the point of view of reducing wastage but there is always the danger that stock may get seeds, dust and barley awns into their eyes, the awns being very difficult to remove. A further advantage of using racks is that where floor space is limited none is lost by fittings as is the case when other systems are employed. Sometimes a trough is placed under the rack so that small pieces of hay falling from the rack are caught, not wasted. One of the most common receptacles used for feeding hay is a round or square crib. Unless special care is taken to keep down the wastage of hay much is pulled or pushed from cribs on to the ground and trodden into the dung. Wastage can be reduced by putting either an old cart-wheel or a cart tyre with 8 to 12 inch wire mesh over the hay in a circular crib; then stock can only pull out a mouthful at a time and little is wasted. The main advantages of the crib lie in the fact that the food is lower than the stock and that reduces the risk of material getting into animals' eyes, and secondly that stock can collect all round the receptacle thereby reducing the trough space required. Calves do not eat much hay, especially when they are young, and a very common way of feeding hay to them is to put it into string nets of 2-inch mesh; they can draw out the hay sufficiently well to eat it but very little, if any, will be wasted. For out-door feeding, racks with troughs beneath lead to the minimum wastage, on the other hand, ordinary cribs are often wasteful. Another way of feeding hay to cattle on pasture is to fix up an old wagon with sides, to load it in the stackyard and to leave it standing in the field; an added advantage is that the wagon is easy to move about the field whereas the hay racks are often big and cumbersome and if left in the same place

for much time stock poach the ground around the racks. Where sheep are kept on pasture or on arable land, hay-racks with galvanized iron roofs are used, or the hay is placed on the ground in a long low swath but with a wooden mesh covering to prevent wastage. For feeding concentrates, no matter whether the stock are housed or at grass, the manger or trough provides a suitable receptacle. With stock at grass small individual iron boxes or pans are often used to ensure that each animal gets its proper share of concentrates; this also provides something which is light and easy to move. For lambs, piglings and calves at pasture creep feeding may be resorted to. A common type of creep feeder for pigs and lambs is a trough, with a wide roof, the sides being fitted with bars to prevent mature stock from gaining access to the food.

A careful stockman is very observant and notices immediately if any animal in his care does not feed properly; he then endeavours to ascertain the reason for the loss in appetite. Meanwhile he must remove food, especially concentrates and roots, that have been left, from before the animal, for there is nothing that puts an animal that is slightly unwell "off feed" more rapidly than stale food. The stockman may try and coax an animal to feed by giving it very palatable foods such as linseed cake and flaked maize; some stockmen go so far as to carry pieces of cake in their pockets as tit-bits for their charges. If an animal does not feed properly for several days it is usually necessary to isolate it and to give it a very palatable ration of succulents and concentrates. It may be necessary to ascertain the particular fancy of an animal to entice it to feed again; the good stockman has patience to study the requirements of ailing stock. Such an animal should not be placed in solitary confinement but in a warm sunny box where it can see and hear other stock; solitary confinement is often sufficient to put even healthy stock "off feed." As soon as any animal is feeding properly and it has been discovered that it has no infectious disease it should be returned to its own pen or box, but if it has been away from other stock for more than a few days bullying may arise and it may receive a further setback. The stockman may have to stand by and see fair play; sometimes the sick animal may be badly treated so that it may be unwise to leave it in a yard even with the stock with whom it had lived previously.

Housing of Stock.

Mention has been made of the fact that some stock are housed whilst others are not. It seems necessary to indicate the various

times, if any, at which farm animals are housed. Sheep are not usually housed at all in this country (except at lambing time), and in many districts the mature animals of the beef breeds spend the whole of their lives out of doors. Young horses are often not housed until they are broken for work; systems of pig keeping are being developed in which the sows live entirely out of doors. Some farmers in the South of England keep their dairy cows outside the whole year round, but it is quite definite that the system would not be of any use in cold, wet, exposed districts in the North of England or on heavy clay soils. During the winter, calves, young store cattle below one year of age and fattening cattle are universally housed, at which time fattening pigs and working horses are also kept indoors. During the summer only very young calves, some fattening cattle and pigs are usually housed. In general all farm animals live on grassland as far as possible both summer and winter for the following reasons,

(1) it is healthier because of fresh air and exercise,
(2) it saves labour of hand-feeding and littering and clearing away dung,
(3) grass, if well managed, is an excellent food,
(4) the stock thrive better than when housed.

It is possible to err in the other extreme and keep stock, that should be housed, outside. Young cattle cannot stand frosty exposed conditions; it is false economy to keep them out on pasture too late into the autumn or too early in the spring so that they suffer from husk. It may be foolish to keep stock on pasture when there is no grass there and food must be carted to them; this is no economy and it is often cheaper to feed indoors in such cases provided there is accommodation. Finally it is a mistake to keep stock grazing when the land is getting poached, i.e. the stock are trampling the wet surface into a quagmire. One writer has pointed out that under such conditions stock have "five mouths," i.e. one mouth proper and four feet. Heavy winter grazing for one season alone may be sufficient to change the botanical composition, and reduce the productivity, of a pasture for several years.

Suckling.

From the above it may be seen that stock of different ages require different provision for housing; they also require different kinds of feeding-stuffs. Very young stock must receive milk as their first food

and as has already been stated they usually thrive better if the milk is from their own respective dams. To obtain the best results young stock must be given a good start; this is usually accomplished by suckling, running dam and progeny at grass, especially during the summer, and in many cases by giving concentrates to the young. In this way the most growth may be obtained at a time when the natural inclination is to grow very rapidly, consequently growth is made relatively cheaply. Weaning is left as late as practicable for the sake of the progeny, for it always produces a slight check in growth; that check is reduced to the minimum the later weaning takes place in the life of the young because then the latter will be eating more other foods and will be less dependent on milk for their nutrients. The old idea of weaning was to do it gradually but in recent years, with higher costs of labour, dams may be removed quite suddenly from their young.

Feeding after Weaning.

For a time after weaning the young stock should be well fed to minimize the effects of the check of weaning, but subsequent feeding depends on the aim of the breeder. In some cases the stock will be fattened and sold as quickly as possible; this will involve feeding forcing rations. Other stock will be required for breeding and some for fattening in later life; in both of these cases a store period will exist. In the years before the World War (1914–18) it was common practice to give stock long store periods lasting in some cases for several years, but latterly the policy of farmers has been to reduce the store period to a minimum. During the store period the ration must at least provide for the maintenance of the animal; with a long store period, although cheap foods may be given, the feeding may be expensive because of the quantity of food used (labour may be greater with a long store period). The store period is essentially a period of slow growth and development previous to fattening or breeding, but it is not a starvation period. In a false attempt at economy some farmers under-feed store animals to such a degree that they starve them; such stunting if carried out with much severity, or for any length of time, may permanently affect the stock, making them long in the leg and lacking in body development. Severe feeding is false economy, for stunted stock will prove most unsatisfactory subsequently. During a store period an animal is usually fed large quantities of rather inferior foods; this is done with several objects in view, namely to consume such foods that are available on a farm, to feed the animal cheaply, and to develop fully its

digestive system. As the time for breeding or fattening approaches the foods may be improved gradually; in the latter case the fattening is usually done as quickly as possible and carefully arranged to coincide with seasonal requirements of the consuming public. Breeding stock should not be maintained in a fat condition but rather they should be in a rising condition when breeding commences. Stock that are very fat for breeding may be temporarily, or possibly permanently, sterile. It is often observed that stock in a high condition for showing will not breed while fat and frequently have to be starved before they will breed. After stock have been successfully served it is not necessary to feed them freely till a short time before the young are to be born. It must be emphasized, however, that it is bad management for pregnant stock to be in bad condition at the time of parturition. A certain reserve of fat is necessary on the dam's body at such a time to provide for emergencies at, and just after, parturition, and also to assist with milk production. It is a mistake to have stock very fat at parturition for that frequently leads to weak muscular action and to difficulties at parturition; at that time normal feeding standards are forsaken and special laxative diets are given, the total quantity of food consumed usually being subnormal. After the animal has recovered from parturition the aim is to feed liberally in the first instance to stimulate milk production. Subsequently the policy depends on the stock in question, sows, ewes and beef cows are usually permitted to produce milk "off their backs," i.e. they lose condition during their lactation periods but mares and dairy cows are quite commonly fed better so that they do not lose condition during lactation. One reason for this, which might easily be overlooked, is that such stock are usually pregnant whilst lactating; that is not the case with the ewe and the sow. Males kept for breeding must never be allowed to get too fat for that may lead to temporary, or even permanent, sterility. Fatness is not the only factor associated with nutrition that may cause sterility; various mineral deficiencies may, in time, lead to lower fecundity and finally to sterility; the minerals involved may be calcium, phosphorus, iron, copper and iodine.

Effect of Food on Quality of the Product.

When the fattening stage is reached it becomes necessary to know the effects of various foods on the quality of meat produced. Generally the oily foods tend to produce soft oily fats in meat, when given to fattening stock, whereas the carbohydrate foods tend to produce hard fat. With cattle and sheep the tendency is to obtain a fat that

is too hard, because roots and barley often contribute largely to the fattening rations but the addition of oil cakes, oats and maize will usually correct this. Fattening on grass leads to a fairly soft fat and it has been suggested that the fattening of bullocks on dried young grass may easily produce a soft fat, but not so soft that it is unpalatable to human beings. With pigs more attention is paid to the condition of the fat than with any of the other farm animals because there is the natural tendency for soft fat to be produced in both bacon and pork pigs. This softness does not influence the flavour but it leads to a greater shrinkage in cooking. The following foods are all rich in oil, which is easily deposited in the body and produces soft fat: soya beans, peanuts, rice bran, rice meal, maize and oats; barley, wheat, peas and beans will counteract this tendency. Other factors that will often produce soft fat in bacon and pork pigs are unfinished (i.e. partly fattened) pigs, those receiving an excess of grain in the ration, unthriftiness, lack of exercise and possibly excessive quantity of water consumed. Bacon factories maintain that the feeding of hotel swill produces bacon with soft fat and several research stations have suggested that giving water *ad lib* increases the amount of fat in the carcase, but opinion is divided on this latter point.

Turning now to the foods that affect butter-fat and milk production, scientific opinion is divided on the degree to which feeding may influence butter-fat production. Some foods are known to stimulate, or to check milk production, and at the same time to have no effect on butter-fat production, it therefore follows that butter-fat percentage may be altered without there being any change in total fat production. In Europe it seems that several of the oil cakes, particularly coconut and palm kernel have, when fed to cows, increased the butter-fat content of the milk without lowering milk yield; the fish oils, especially cod-liver oil, appear to depress the butter-fat content of the milk. What is, however, often more important than the mere quantity of the butter-fat is the ease with which the fat can be made into first-class butter; here opinion is much more unanimous that foods very definitely influence the butter produced. When any of the following foods, which may contain high percentages of oils, are given freely hard butter may ensue, pea meal, bean meal, cotton cake, cotton-seed meal and coconut cake, whereas soya beans, peanuts, linseed cake, maize and several of the maize products lead to butter with a soft oily texture. Young pasture grass produces soft butter, and it is quite likely that dried young grass would have the same effect, but the last point is not of very great practical importance because butter is not made in large

quantities in the winter when whole milk commands a high price.

Another way in which foods may affect produce is by giving rise to taints. No food has been more maligned than fish meal on the score that when it is fed in large quantities it may produce a taint in the bacon or pork obtained from the pigs eating it; if, on the other hand, a good sample of fish meal (i.e. low in oil content) is fed in a reasonable quantity perfectly good meat may be obtained. Fish meals containing a high oil content should not be given to fattening pigs at all, because, even when fed in small quantities, taints may be produced. So much trouble has been experienced in the past from feeding fish meal that some bacon factories refuse to accept pigs that have received fish meal in their rations. Some pastures contain wild onion as a weed, rendering them unsuitable for grazing by dairy cows in milk, but such pastures may be grazed by fattening sheep and cattle, although it is considered to be a wise precaution to remove the stock for a fortnight to another pasture to allow the onions to leave their digestive systems before slaughtering. Foods are much more likely, however, to produce taints in milk and great care must be exercised in selecting foods for milk production. Taints in milk are from two sources, either from the food the stock have consumed, i.e. an internal taint, or from odours in the cow-shed, i.e. an external taint. Usually feeding-stuffs do not produce external taints, but there is one food that may give rise to trouble and that is silage. If silage is fed to cows in the cow-shed the aroma may remain in the shed till milking time, and then milk, being very absorbent, where odours are concerned, will take it up; this difficulty is quite easily overcome by feeding the silage outside the milking shed. Of the foods causing internal taints turnips, swedes, cabbage and rape have caused most trouble in the past; more recently kale may be added to this list; where it is practicable these foods should be omitted from the rations of dairy cows unless given freshly cut. If there is no alternative food it is possible to feed limited quantities but they should be given immediately after milking; thus the odour may leave the system before the next milking time. Sugar-beet tops and the various forms of sugar-beet pulp have also been accused of producing a "fishy" taint in milk; this is quite likely to occur with the former but very unlikely with the latter, provided not more than 10 lb. of the dried pulp are included in the daily ration. Unwilted beet tops are most likely to produce tainted milk, but if they are fed to cows after wilting and given immediately after milking time then the possibility of producing a taint is very much reduced. Even grass itself may produce a slight grassy flavour in the milk, when

cows are first turned to grass early in spring, but usually the taint disappears as soon as the cows become accustomed to eating spring grass. Turning to the concentrates, it is almost impossible to produce a taint provided the foods are sound and free from impurities. One of the worst impurities that may be found is garlic—especially the wild onion which may be present as seed in cereals. No cereal containing wild onion seed should be given to dairy cows in milk but rather to store or working stock. Taint may arise from hays, sometimes from the hay itself, but much more commonly from the weeds included. Some readers may be rather surprised to read that hay itself may produce taint but experience shows that lucerne hay has given trouble in the past; this may be remedied by feeding it four or more hours before milking time. The worst weeds found in hay are wild onion (stems of which are present) camomile and possibly some species of buttercups; a number of weeds are always viewed with suspicion, e.g. butterwort, henbane, several of the cresses, water parsnip and wormwood. Sometimes the taint may arise in late winter after a long period of feeding on winter rations and especially if many cows are well advanced in their respective lactations; then the milk is frequently bitter in flavour and possibly a little salty. This may be remedied by merely changing the mixture of concentrates fed and by giving the cows laxative medicines to clear out digestive tracts. It seems that a cow may become stale as a result of continually feeding the same concentrated ration, although none of the ingredients may directly cause the taint.

Food as a Factor in Disease and Parasite Causation.

Foods may give far more serious troubles than taints, namely diseases. It is well known that the use of purchased foods and litter have been the means of introducing in a few cases, diseases to a farm, such as foot and mouth disease. This disease may be carried in concentrates and especially any meat bones or offal that have not been properly cooked, or if the concentrates have been in contact with animal by-products, also hays and straws may carry that infection; it is for this reason that, in general, foreign hay and straw are not permitted to be landed in this country unless they are used as packing material. Anthrax occurs spasmodically in this country and investigation of the probable sources shows that in two-thirds of the outbreaks imported concentrates have been the source of infection. Although swine fever is not usually carried to a farm in the food itself it is quite likely that bags in which foods are put, may be the means of spreading the disease wherever there is an outbreak,

especially if the practice of returning empty meal bags to merchants is resorted to. Since tubercle bacilli can live for a period of three to six months outside the animal body it is quite obvious that the bacilli may be carried on various purchased feeding-stuffs entering the farm, especially if they are from other farms and not from manufacturers; in the case of meat residues there may be real risks unless the residues have been thoroughly cooked. Much the same applies to Brucella abortus, the bacterium that is responsible for bovine contagious abortion; that, too, survives for similar times to tubercle bacilli and may be spread in similar ways. From the above it will be observed that some diseases may be brought on to a farm on purchased foods but in many cases the movement of food-stuffs about a farm may possibly lead to more trouble. When there are several homesteads, and there is an outbreak at one of them of one of the above diseases, movement of cattle, or of foods, from the infected to the free homesteads may easily spread the disease. Whenever any stock are ill, foods intended for other stock must be kept isolated from the sick stock. The easiest way of infecting feeding-stuffs, and of spreading disease, is by sick stock constantly passing a stackyard or a Dutch barn containing hay and for fæces and other discharge to be scattered over the hay.

From time to time, even the best farmers find their stock, and especially their young stock, suffering from internal parasites; this may be the direct outcome of mismanagement, and feeding may be at the root of the trouble. Many different kinds of internal parasites are present in the digestive tracts, and occasionally in other parts of the various farm animals and no harm may be done provided the stock remain healthy. If, as may be the case, the stock receive a check, either from illness or from wrong feeding, then the parasites may suddenly become more numerous and the host may become exceedingly emaciated. It is possible for stock with internal parasites to eat well but to remain unthrifty, in a poor condition, and with unhealthy looking coats; sometimes hacking coughs may give further symptoms of the particular parasite present. In these cases feeding the pest is not the remedy—the parasites must be attacked. The methods of attack vary with the parasite and also with the part of the animal in which the parasite lives. Many parasites are present in the digestive tract and for these liberal feeding of the host merely provides more food for the parasite. In general the method of treatment for the parasite in the digestive tract is relatively simple. In the first place the animal should be starved for about twenty-four hours to empty the tract of food and so facilitate the attack on the

parasite; by this time the parasite is usually given something that is poisonous, in as large quantities as are safe to increase the effect. The parasite having become lethargic and unattached to the host, a purge is then given to expel it from the host. Care must be taken to see that the parasites are not expelled on grassland (for they are not usually dead), but as far as possible on concrete or on arable land to which stock will not return for some time.

Feeding Costs.

This chapter will not be complete unless some mention be made of costs. Ultimate success of feeding must largely depend on utilizing the cheapest foods in any particular season and of utilizing, or selling, home-grown foods if it is economically worth while to do so; sometimes high feeding costs are due to excessive costs of home-grown feeding-stuffs. It must be remembered that food costs play an important part, usually the major part, in the cost of obtaining animal products. It is not possible to have a constant system of rations for all time but it must be flexible to allow for changing prices. Sometimes it will be economic to grow and feed the maximum quantity of roots rather than to utilize carbohydrate concentrates. In calculating costs the mere cost per ton will not be the only criterion of comparison; analysis of the feeding stuff must also be considered, i.e. the cost per unit of starch equivalent or protein equivalent has to be calculated in such cases. The following tables give comparative costs of various foods per unit of S.E. and P.E. at the prices per ton quoted.

COMPARATIVE COSTS OF STARCH EQUIVALENT

Food	S.E. %	Price per Ton	Price per Unit of S.E.
		£ s. d.	£ s. d.
Barley meal	71	10 0 0	2 10
Dried sugar-beet pulp (merchant's price)	61	5 10 0	1 10
Dried sugar-beet pulp (grower's price)	61	4 10 0	1 6
Mangolds:—	6·3	1 0 0	3 2
or :—	6·3	10 0	1 7

COMPARATIVE COSTS OF PROTEIN EQUIVALENT

Food	P.E. %	Price per Ton	Price per Unit of P.E.
		£ s. d.	£ s. d.
Linseed cake	25	10 10 0	8 5
Dec. ground-nut cake..	41	8 10 0	4 2

Thus if a ration is required for a particular class of stock it behoves the feeder to endeavour to feed the stock as cheaply as possible provided he does not waste perishable, unsaleable, home-grown foods. It may be possible in a case of this sort to modify the cropping scheme if home-grown foods seem to be too expensive for use.

Hay and straw should not be omitted from the question of costs. If very good hay is available and it commands a good market price, it may be a sound policy either to sell it for cash or to store it for the future and to use straw and possibly protein concentrates as a means of reducing costs. This is quite a sound way of reducing the cost of feeding store stock, provided concentrates are cheap and hay is expensive. Good hay may reduce the quantity of concentrates fed and every farmer should do his utmost to produce as much first-class hay as possible. It is quite obvious that it is impossible to be dogmatic on the subject of feeding in which flexibility must be the keynote of success.

IX

FEEDING REARING CATTLE

The Feeding of Calves. From Birth to 3 Months.

SINCE beef and dairy calves are both reared by the same methods it is proposed in this discussion to consider the rearing of calves of all kinds. There is no doubt that it is costly to rear calves from birth till they are three months old, i.e. until they may live entirely on foods other than milk; some breeders feed milk till calves are at least six months old, but this adds further to the cost without necessarily producing better progeny. It therefore behoves the breeder, or rearer, to ensure that only stock of sufficiently good breeding and those likely to be of value to the fattener or milk producer are reared. The only way a dairy farmer can maintain, or improve, his dairy herd and keep it free from disease is by breeding and rearing his own heifer calves; the best way for a feeder to obtain reliable store cattle is to breed them himself but there are many complications in such a policy. In view of the high cost of the initial stage of rearing it is essential to review, critically, the various methods of rearing beef and dairy cattle; there are at least half a dozen different methods commonly practised in this country, and also several variations of some of these systems.

The calf should commence its life by receiving milk (actually colostrum) from its own dam, another dam, or milk reinforced with castor oil. The main systems of calf rearing that will be described are:

(1) Suckling its own dam,
(2) Suckling a foster mother or a nurse cow,
(3) Pail feeding with fairly large quantities of new milk,
(4) Pail feeding with limited quantities of new milk and gruel feeding.
(5) Pail feeding with limited quantities of new milk and dry concentrates,
(6) Pail feeding with limited quantities of new milk together with milk by-products and concentrates.

In addition to milk all calves should receive other foods as soon

as they are three weeks old, for, although milk is the ideal food for young animals, it does not provide any fibre; this becomes an essential in the diet of ruminants as soon as their four stomachs are sufficiently developed to digest fibrous foods. Indeed it has been proved, experimentally, that calves kept on an all-milk diet eventually die. In a very short time the natural demand for fibre may be so acute that a calf, if given no fibrous, or bulky, food, may eat its bedding and, by the time it is six months old it may start to eat wooden fixtures in its box or yard. Usually, as soon as a calf is three weeks old hay should be given but in such small quantities that a fresh supply may be given almost daily, unconsumed hay being removed and given to store cattle. The quantities of hay eaten will be, on the average, ¼ lb. per day at first rising to 2 lb. per head at three months; good meadow hay is ideal at this young age. It is not usually wise to feed succulent foods to calves under the age of two months unless the calves are suckling cows which are at grass; in that event the calves naturally eat a certain limited amount of the grass. After calves reach the age of two months they may be given a small quantity of sliced roots daily, e.g. up to 5 lb. of mangolds or swedes. Concentrates may be given from the age of 3 weeks, in addition to the hay. There are no very accurate feeding standards available for such young stock, and all that one can do is to recommend tried mixtures of concentrates which may be used as general mixtures themselves or with the addition of supplements which are essential with certain systems of calf rearing. Typical concentrated mixtures are:

(1) 1 part* Linseed cake,
1 part Beans (whole or meal),
1 part Crushed oats or flaked maize.

(2) 4 parts Linseed cake,
5 parts Bean meal.

(3) 4 parts Linseed cake,
5 parts Fine weatings,
1 part Dried yeast.

(4) 2 parts Linseed cake,
1 part Crushed oats or flaked maize.

(5) 1 part Linseed cake,
1 part Cracked beans,
2 parts Crushed oats,
1 part Flaked maize,
¼ part Fish meal.

* Here and subsequently, unless otherwise stated, part by weight is assumed.

(6) 3 parts Linseed cake,
3 parts Cracked beans,
2 parts Crushed oats,
1 part Flaked maize,
1 part Fish meal.

Calves are rather liable to suffer from deficiencies of vitamin B and D, especially when housed in dark boxes or sheds during winter months; such calves should be given a small quantity of cod-liver oil as soon as they reach the age of six weeks. One teaspoonful with concentrates twice daily will usually be sufficient to ensure sound growth; cod-liver oil is particularly necessary whenever calves are reared on small quantities of milk. As soon as calves begin to eat dry foods, and especially where the quantity of milk available is limited, they require water to drink. The opinions of practical men are very divided on the subject, but experience shows that it is quite safe to give water *ad lib* to calves and that the leaving of water constantly before calves does not lead to their becoming "pot-bellied." By the time a calf is three months old it may be drinking as much as 0·5 to 1 gallon of water daily.

Experience shows that calves will lick rock salt at quite an early age and as a general principle it should be placed before them almost as soon as they are born. Some authorities consider that other minerals need not be supplied if calves receive fish meal in their ration; this has proved quite sound in practice. Others advocate the use of a general protein-mineral mixture to be used in conjunction with crushed oats and linseed cake such as that recommended by some Scotch workers:

10·18 parts Blood meal
2·40 parts Chalk
1·15 parts Potassium chloride
0·66 parts Sterilized steamed bone flour
0·50 parts Sodium chloride
0·10 parts Ferric oxide
0·01 parts Potassium iodide,

the above to be fed at the rate of 7·5 parts of mixture to 100 parts of concentrates; in this case ⅛ oz. of cod-liver oil should be given daily till the calves reached 8 weeks of age and thereafter this quantity should be increased to ¼ oz. daily.

In general, mineral feeding to calves is not necessary, especially when large quantities of milk, or milk products, are available and provided the stock are not being reared in what are known as mineral deficient areas. In the latter case a particular mineral will be lacking

from the soil, then all crops grown on that soil will contain a sub-normal amount of that mineral; hence stock eating home-grown foods may suffer from the mineral deficiency.

Natural Rearing of Calves. The most natural way to rear a calf is to allow it to suckle its own dam, and experience shows that, in general, a calf makes the best live weight gain when reared in this way. The reasons for this are that:

(1) the milk is of the correct chemical composition for the calf, which is especially important immediately after the calf is born, because then the cow produces colostrum which is high in protein and has laxative properties,

(2) usually the calf can take the milk in small quantities, and at frequent intervals, thus resulting in less digestive disturbances,

(3) the milk is obtained at the correct temperature,

(4) the milk is free from bacterial infection provided the dam's udder is perfectly healthy,

(5) the calf will usually take milk from the udder by instinct; no lessons being necessary to teach it to suckle.

Usually the minimum of labour is involved with this system. Although the system has so many points in its favour it is not widely practised because of the cost and also because a good cow will produce more milk than a calf can take; then milk is left in the udder, the yield falls, quarters may be lost, and the udder may become misshapen. If a cow rears only her own calf during the course of a year, she is bringing in a very small income; the calf has to pay for the cow's keep, labour, depreciation for the year, also for a service fee, and its value, except in special cases, is not usually sufficient. The very low milk yield of 400 gallons from a cow is worth about £20 and if a calf has consumed that quantity of milk the rearing cost is enormous; some cows who give double the above quantity of milk are used for calf rearing, but a different system must be adopted. Usually the only occasion where it is financially sound for a calf to suckle its own mother is in the case of a pedigree bull calf, which, if it is reared well, may command a very high price. In some cases, and particularly with the beef breeds, dams may have insufficient milk to suckle their own calves and then the services of a nurse cow are enlisted; in some extreme cases beef bulls may have received milk from their own dams for a time and later from one, and in some cases from two, nurse cows. These bull calves will often suckle till they are 12 to 15 months old by which time they are so large that it is only with considerable difficulty that they can suckle; then, to facilitate suckling, the nurse cow may be placed on a plat-

form or pedestal. Normally a dairy cow does not suckle her own calf for more than four days because she will produce more milk than the calf will require, and a number of breeders wish to record the yield of milk produced by the cow; recording is not permitted, nor is it possible, when a calf is suckling a cow. The only occasion when a dairy calf suckles its own dam is in the case of a dairy cow that has, in a previous lactation given a good milk record, but because of some slight disability is not retained for milking but for breeding. In such cases a dam will usually rear some calves in addition to her own unless her own is a bull calf and he is being fed liberally for sale. Most breeders wish to purchase bulls for breeding when they are ready for service and they demand bulls well developed for their age; well-grown calves are assumed to be from thrifty families, hence the demand for well-grown stock. This good development for age can be most easily and certainly produced when a calf suckles a cow for a long period. For the ordinary commercial animal destined for milk or beef production the rearing of one calf on its own dam in general cannot be recommended because of cost.

Suckling of calves on foster mothers is a system of rearing very commonly found in some districts of this country. In dairy herds a few cows with only three quarters may be retained for breeding, and, in addition to rearing their own calves, they will rear several others during each of their lactations; usually, in cases of this sort, the calves will remain in buildings while the cows run with the dairy herd and are brought in to their respective calves when the other cows in the herd are brought in for milking. Sometimes a foster mother suckles only two calves throughout lactation and then the cow and her calves run together on grassland throughout the summer. Another system is to keep a herd of dairy cows, but instead of bringing them in for milking they are brought in for suckling twice daily; provided there is a sufficiently large supply of calves a herd of this kind may rear, on the average, about six* calves per cow per year. This system is most commonly practised on inaccessible outlying farms, well suited for keeping dairy cows but with difficult communications for the sale of liquid milk. At times when the fattening of cattle in yards is uneconomic some farmers who have large yards, plenty of straw, and require farmyard manure for arable land, have turned to this system of suckling calves on cows as a better financial proposition than fattening bullocks. Calves reared in this way are usually commercial stock destined either for dairy herds or to be fattened for beef production. The last

* Some breeders claim 12 calves per cow per annum!

example of fostering is the one already mentioned above where a foster-mother is required to supplement the milk produced by a bull calf's own dam. In all of these cases foster-mothers must themselves breed regularly each year; it is difficult to arrange for calvings to take place at the right time each year and also for a sufficiently large number of calves of the right type to be available as required. Calves for foster-mothers are usually purchased, and to ensure a supply of calves of the right type, some farmers have provided neighbours with bulls on condition they will sell them all calves born at an agreed price for rearing on foster-cows. It may prove difficult to persuade the purchased calves to suckle their foster-mothers. For success a calf should suckle its own dam before it is put on a foster-mother, and a minimum time should elapse after suckling one cow and proceeding to the next. If the calf must, in the meantime, be fed from a bucket (the difficulties associated with this change will be discussed, p. 174), it is exceedingly difficult to change a calf from bucket feeding back to suckling. Another difficulty that is found in connection with fostering calves is that some cows are excellent foster-mothers whilst others are so lacking in maternal instinct that they will not even allow their own calves to suckle them; cows of the latter type are of course useless as foster-mothers. A cow will usually know her own calf and she will allow it to suckle her, but if a foster-calf is added she may kick the latter whenever it attempts to suckle her. In such cases, where a cow has sufficient milk to rear two calves, it may prove an advantage to remove the cow's own calf and to give her two foster-calves; then she has two calves to attack simultaneously and usually she admits defeat and allows both to suckle. When a fresh calf is given to a cow for fostering it may be necessary to tie the cow up, e.g. to halter her, to prevent her from wandering from the calf and in some cases it may be necessary to strap her legs to prevent her from kicking the calf. When a fairly good milking-cow is used as a foster-mother she may easily rear eight calves a year, at times she would be suckling three calves a day and each calf would suckle for about three months:—

1st calf	0	till	13	weeks	after calving.
2nd calf	1	,,	14	,,	,, ,,
3rd calf	3	,,	17	,,	,, ,,
4th calf	14	,,	27	,,	,, ,,
5th calf	15	,,	28	,,	,, ,,
6th calf	18	,,	31	,,	,, ,,
7th calf	28	,,	41	,,	,, ,,
8th calf	32	,,	45	,,	,, ,,

Fostering usually demands the care of an efficient stockman, for much patience is necessary whenever fresh calves are being suckled on a cow.

Artificial rearing of Calves. All other systems of calf rearing involve pail feeding and it is essential to describe the main features of pail feeding, together with a criticism of the ways in which they may be carried out in practice. It is always difficult to teach a calf to drink milk from a bucket; the difficulty being increased the longer the calf has suckled a cow. To suckle, the calf turns its head "up hill" whereas to drink from a bucket it must turn "down hill"; usually a calf is slow to understand that a change in direction of feeding is essential. When it is necessary to teach a calf to drink the stockman should (*a*) back a calf into a corner of a box or pen, (*b*) stand astride the calf, (*c*) hold the bucket in one hand and (*d*) put the fingers of the other hand, after they have been moistened with milk, into the calf's mouth, so that the palm of the hand rests on the calf's nose. With a little pressure the calf's head may be pushed into the bucket while it is still sucking the stockman's fingers. Provided the calf continues sucking it will soon draw up milk from the bucket but between the stockman's fingers; in a day or two the hand may be dispensed with and the calf will drink from a bucket. In order to avoid the difficulty of changing from suckling to bucket feeding it is usually easier to start the calf on the bucket system at birth provided the calf receives colostrum from its own dam. Certain features of routine must be observed if calves are to be successfully reared: (1) calves under three weeks of age preferably should be fed thrice daily, twice daily sufficing at later ages, (2) feeding must be done at regular times daily, (3) the milk must be given at the correct temperature (100 degrees F.), (4) the calf should be underfed rather than overfed, and (5) cleanliness of buckets is essential. All of these points, if carefully observed, will reduce the incidence of digestive troubles. Bucket-fed calves should be kept in individual pens or they should be tied up for a short time after each feed of milk as a means of preventing them from suckling one another (navels when sucked may become festered). With bucket feeding it is usually possible to entice a calf to eat concentrates by sprinkling a handful of these foods into the bottom of a bucket whilst there is still a small amount of milk remaining; in an attempt to drink all the milk some concentrates will be consumed. Rearing on the bucket is usually less expensive than rearing on a cow because less milk is consumed, but unless great care is taken bucket feeding will lead to far more digestive

troubles than will be experienced with suckling; digestive troubles are usually indicated by the calf scouring. With calves of the Channel Island breeds the natural milk may be too rich for the young calves, and it may be necessary to dilute fresh milk either with water, or with skim milk, to reduce the risk and incidence of digestive troubles.

It is very rare that calves are fed on unlimited quantities of new milk because milk is too valuable for wasteful feeding. Occasionally special pedigree stock or animals being prepared for showing may be given unlimited quantities of whole milk but much more commonly the supply of whole milk is limited.

Many farmers who have only a limited supply of new milk available for calves try various milk substitutes to replace new milk. Experience shows that it is unwise to reduce the quantity of new milk required for rearing one calf below the level of 30 gal. and that 80 or 90 gal. produce optimum results; it is usually foolish to feed anything but fresh whole milk to any calf under the age of three weeks. A very common belief amongst farmers is that new milk should be replaced by a wet food such as gruel, but there is no evidence that this is really true, and usually more digestive troubles occur when gruel is fed than when dry concentrated foods are given. The making of gruel is hardly a process for farm labourers for it requires careful boiling and stirring of the mixture and is really better done in the farmhouse kitchen. There is no doubt that gruel feeding is quite a nuisance and calves are very liable to receive badly cooked foods which may cause digestive disturbances. Gruels may be made from meal mixtures, as follows:

(1) 2 parts Linseed cake,
2 parts Oatmeal,
1 part Ground linseed.

(2) 6 parts Pea meal,
3 parts Ground malt,
1 part Ground linseed.

(3) 1 part Linseed cake meal,
1 part Fine weatings.

In addition, there are a number of proprietary mixtures that are quite satisfactory; experience shows, however, that the meals containing milk products, e.g. dried milk (skimmed), dried buttermilk or possibly dried whey are the best. To make gruel usually 1 lb. of meal is added to 1 gal. of water and the mixture is slowly heated to boiling point, then after several hours of cooking the gruel is ready for feeding.

Boiling is essential for destroying the prussic acid that is often produced when water is added to linseed products. When gruel feeding is done it is usually commenced when a calf is three weeks old (some advise at two weeks of age) by replacing a pint of milk with a pint of gruel and increasing the substitution of 1 pint per week until after several weeks the gruel will have replaced all the whole milk being fed. Almost immediately the maximum is reached the quantity of gruel fed daily (then about 1½ gal.) is reduced gradually so that none is fed by the time the calf is three or four months old. With gruel feeding hay must be available together with concentrates as soon as the calf is three weeks old. Some farmers think gruel dispenses with the necessity of giving concentrates, but it is not so, for a calf must be eating much concentrates by the time that gruel feeding is discontinued.

Using dry meals is equally as satisfactory as the feeding of gruel, and since the former is much simpler it is less likely to cause digestive trouble, demands less labour, it is the system that can be recommended most strongly. It is possible to rear calves on this system with as little as 30 gal. of new milk but far better results may be obtained by feeding 50 to 90 gal. of milk per calf; many breeders consider these latter quantities worth while from the results they obtain. Meal should be offered to the calf as soon as it is three weeks old, at which time the quantity of milk will commence gradually to fall until eventually none is fed when the calf is 8, 10 or 12 weeks old. The quantity of meal that may be consumed by the time the calf is three months of age is 2 to 2½ lb. daily; hay will be fed at the same time and in the same quantity as the concentrates.

When liquid whole milk is expensive substitutes are sought to replace it in calf rearing. Frequently dried skimmed milk is in the market at prices* between £20 and £30 per ton which represents a price of approximately 2d. to 3d. per lb. If 1 lb. of dried skimmed milk is added to 9 lb. of water a reconstituted skimmed milk is produced which may, to a large extent, replace 1 gal. of whole milk which may have a value of 1s. or more; all that is necessary to provide about the same amount of nutrients, as are present in 1 gal. of whole milk, is to add 1 lb. of carbohydrate concentrates to the reconstituted skimmed milk; which means that the latter ration will cost 4d. compared to the 1s. or more for whole milk that it replaces. It is quite possible to replace whole milk by such skimmed milk and carbohydrate concentrates on any dairy farm. In some districts and on some farms, ordinary skimmed milk (or possibly

* 1938 prices used here.

more correctly, separated milk, the difference being that separated milk is obtained when cream is removed from milk mechanically and consequently more efficiently than if by hand when the residue is known as skimmed milk) is available in relatively large quantities for calf feeding. Some dairies offer skimmed milk to farmers at low prices (17 gallons for 1s.) provided the farmer pays for carriage, but it should be pointed out that there is the risk that disease, in particular tuberculosis, may be present in the milk, especially if it has not been pasteurized. No matter whether skimmed milk or reconstituted skimmed milk is used a small quantity of carbohydrates must be fed in addition to the amount fed when whole milk is used. The quantity of either kind of skimmed milk may be the same, namely up to 2½ gal. daily, but at times far greater quantities are fed when large quantities of ordinary skimmed milk are available and must be used. This skimmed milk may be used with safety as soon as a calf is four weeks old and then the quantity will be 1 qt. of skimmed to 3 qt. of ordinary milk daily, the 5th week it will be 2 to 3 daily; the 6th week it will be 3 to 3 daily; 7th week 5 to 2 daily; 8th week 8 to 1 daily and the 9th week 10 qt. daily (of skimmed milk). The quantity may then be reduced as slowly or as rapidly as the supply permits; the above scheme uses some 42 gal. of whole milk and some farmers have found it is possible to reduce this figure to 12 gal. It might be stressed that the first scheme is a little conservative, though quite safe, but one research worker has advocated the use of reconstituted skimmed milk when a calf is only three days old. Suitable additional foods that may be used when skimmed milk is being used are:

(*a*) For very young calves good grade cod-liver oil may be added to replace the lost fat—commencing with ½ oz. daily and increasing gradually till a maximum of 4 oz. daily is reached when the calf is 4 to 6 weeks of age, greater quantities may lead to scouring;

(*b*) To increase the proportions of carbohydrate foods shown in the ration on page 169, e.g.

$$(2) \begin{cases} \text{2 Linseed cake} \\ \text{1 Crushed oats} \end{cases} \textit{becomes} \begin{cases} \text{2 Linseed cake,} \\ \text{2 Crushed oats.} \end{cases}$$

It must be emphasized that it is very undesirable to feed a calf on fresh milk one day and sour milk the next as it leads to scouring, either being quite satisfactory provided it is fed constantly in that form; if there is any doubt about the skimmed milk keeping sweet till feeding time the policy should be to feed sour milk deliberately.

A relatively large number of farmers in this country have whey available for calf rearing. Whey, being the residue from cheese

making, contains very little protein or fat, although it must be remembered that the protein that is present is of high biological value; in consequence more protein must be fed in the concentrated mixtures than when skimmed milk is the by-product being used. The same quantities of whey, and for the same duration, may be fed as for skimmed milk described above, except that precipitated bone phosphate should be added at the rate of ½ oz. to each gallon of whey. Concentrated rations to be used in conjunction with whey must be high in protein as is evidenced by the following ration which in one trial proved to be the best concentrated ration used:

3 parts Linseed meal
3 parts Bean meal
1 part Fish meal,

this was very closely followed by a ration consisting of

5 parts Bean meal
4 parts Linseed meal.

Dried whey and also whey paste are on the market and provided they are brought to the same water content as is found in ordinary whey, they may be used as described above for ordinary whey.

The feeding of dried grass, or dried lucerne, to calves has not been fully studied, but the results obtained up to the present suggest that about half the normal concentrated mixture may be replaced with good quality dried grass or dried lucerne. When it is the policy to feed mixed calf meals it is convenient to use the meals of either of these dried products but if calf cubes, or relatively coarse cakes are used then the unground dried foods should be used. If only poor quality dried grass (more commonly called super-hay) is available then it should not replace concentrates in the ration, but rather the hay. There is no reason why the dried products should not be used as soon as the calf starts eating solid food, i.e. when 3 to 4 weeks of age. Experience shows that the use of these dried milk products puts a good bloom on the coats of the stock eating them.

Calf Rearing. 3 *to* 6 *Months.*

When calves are to be reared at a minimum cost they receive no milk either as whole milk, skimmed milk or whey after they reach the age of three months; in pedigree herds where plenty of growth is required at an early age for sale purposes, milk feeding may be continued till the calf is six (and sometimes fifteen) months of age. In such cases the daily rations will very rarely, if ever, exceed those mentioned in the above cases but the general policy will be to con-

tinue feeding at the higher level for a longer period than is given above. There is no doubt that when weight for age is required and cost recedes into the background, milk, or milk products, cannot be replaced by any other foods for young stock.

Since it is impossible to discuss the feeding at all ages of weaning it is proposed to consider that of three months. At that time the calf, either male or female may be receiving to 2½ lb. of concentrates and about the same quantity of good quality hay, rock salt and water being available always. The simplest scheme is to continue with the same ration that has been fed, to increase the concentrates and hay gradually so that 4 to 5 lb. are being fed (depending on the size of calf) by the time it is six months old. It is possible to restrict the hay to 2 lb. per head per day and to feed roots and silage instead at the rate of up to 5 lb. of silage or up to 10 lb. of roots. No attempt should be made to give poor quality foods to calves under six months of age in an endeavour to reduce costs; it is usually false economy. Furthermore, calves under six months of age should be housed, even in summer, unless they are suckling a foster-mother or their own dams, but to reduce housing costs it is not necessary to keep calves in individual pens, if that has been the policy, after milk and milk products have been omitted from their rations. At this age most stock in this country are handled as stores but those in pedigree herds being forced for sale will be fed similarly to those for baby beef production. The rearing in the latter case will be described in the section on fattening cattle.

When calves reach the age of three months it is possible to replace the whole of their concentrated ration by good quality dried young grass almost on a pound for pound basis, except that when 4 lb. of concentrates should be fed the quantity of dried grass should be about 4½ lb. Again, as with younger calves, dried grass of poorer quality may be used to replace good quality meadow hay on a pound for pound basis.

The Store Period. 6 *to* 24 *Months.*

Whether destined for dairy herds, or for fattening in yards, or at grass, the feeding of ordinary commercial stock (and of pedigree dairy heifers) will follow the same general system, namely, of giving rations containing large quantities of roughages, or grass, and relatively small quantities of concentrates—such rations are known as store rations. A store animal is required to grow slowly, and to gain in live weight, but it is not expected to get fat. It should, however, be given large quantities of bulky foods to consume so

that its digestive system is well developed and, in the case of the dairy heifer, rendered capable of dealing with a large quantity of food. Some farmers are too severe on store cattle and feed more or less starvation rations containing too little protein or too little minerals; this is a gross mistake for the store ration must never stunt the animal. Stunting leads to far more serious results than are usually realized, for generally a stunted animal does not recover even when fed properly, and reach normal development. During stunting the animals continue to grow in length of head and length of legs, whilst other parts do not grow with the result that the skeleton is altered so that when a normal ration is fed the animal becomes badly proportioned; usually it may be described as being leggy, lacking in body development and pelvic girdle, and with a large coarse head. Another disadvantage of stunting lies in the fact that when an animal that has been stunted is fed a normal ration it has so much lee-way to make up that it will not make normal live weight gains; a stunted animal's digestion does not work effectively, so, when the animal receives a normal ration, for a time, it is unable to cope with it and either the animal has such a small appetite that it cannot eat the ration offered or alternatively the ration passes through the animal incompletely digested.

In most districts store cattle, of all ages, can spend the summer out at grass, in which case it is rare to feed any supplementary food whatsoever, unless there is a very severe drought. Store cattle are not usually given the best, but the worst, grazing that can be found on a farm; the latter, however, may be very luscious during parts of the grazing season and may lead to trouble when the stores are turned out on it. The troubles that are likely to arise from young grass are scouring and "blowing"; the latter is due to the production of large quantities of gas in the rumen leading to extreme distention, thereby pressing on the heart and lungs and sometimes causing suffocation; stock with distended rumens are said to be "blown." At such times several precautions may be taken to reduce the possibility of such troubles arising, namely:

(*a*) the stock may be housed at night and fed roughages, and run out for limited grazing during each day;

(*b*) the stock may be turned on to poor, bare pasture and then allowed to graze better pasture for a limited time each day;

(*c*) the stock may be fed roughages while grazing succulent pasture (this is usually a failure because stock will not eat roughages when grass is available).

In the first two cases the time allowed for grazing, on the better grass,

may be increased daily as the stock become acclimatized to the luscious growth. When stores have commenced grazing in the spring no real difficulties are likely to arise till either a wet spell of weather occurs and grass grows very suddenly, or the stock have to be moved to a pasture containing luscious grass; again changes must be made gradually to reduce the risk of "blowing" or scouring. In general, store stock will be put on the poorer grassland where the risks of "blowing" and scouring are less, but nevertheless still exist. In some cases store stock may be assigned to a field and, provided there is plenty of water and a fair growth of grass, they may remain there all summer; many marshes are grazed in this way. Another possibility is to use store cattle as followers behind dairy cows (both in-milk and dry) beef cows, breeding horses and young horses. Sometimes store cattle are used in conjunction with sheep to keep the land well grazed. Where store cattle are used as scavengers they will, of course, be moved around the farm to fields wherever there is an excess of grass that has been left, either over the whole field or in tufts. The best store stock for scavenging are those over the age of eighteen months, the others, younger stores, are usually assigned to poor quality grass fields.

If, on the other hand, the stock are to be at grass during the winter it may be necessary to give a certain amount of food in addition to the grass, in most localities in this country only the stock over eighteen months of age will remain out at grass all winter; this will, of course, depend to a large degree on the nature of the soil, for clay pastures usually poach up badly if grazed by cattle during the winter. Stock remaining outside during that period of the year will receive supplementary rations depending on the amount of grass available; if there is much old "foggage" to be consumed no supplementary feeding will be necessary. If, on the other hand, there is very little grass then it will be necessary to feed large quantities of the straw, poor hay or possibly a combination of good or medium quality hay and straw. Whenever vast quantities of poor hay or straw are being fed there is always the danger of giving too little protein to stock and, as a general rule, up to 2 lb. of high protein cake, such as decorticated ground-nut cake, will be necessary daily. When there is a good supply of grass, supplementary feeding with roughages will be necessary only when the grass is covered with snow and the cattle cannot graze; experience shows that at such times stock will eat more roughages than they would consume during normal temperatures and the usual policy in rough weather is to feed freely. The only other time that store cattle running at

grass may require additional food is when they are first turned out in the spring, after being housed all winter; in order to prevent scouring they may be brought in at nights and given a large ration of hay or straw before they are turned out for grazing in the day time; alternatively they may remain out at grass and receive undecorticated cotton cake at the rate of up to 4 lb. per head per day. It should be stressed that all young store cattle are liable to suffer from husk if they are on pastures very early in the spring or very late in the autumn, and the incidence of husk varies from season to season and also from locality to locality; in most districts even in the south of England stock under one year must not be turned out to grass till May and they must be in, certainly for night, by early September.

Housed store cattle may be kept in boxes or yards; where there is sufficient straw available for bedding the housing of groups of up to twenty beasts in yards provides the cheapest way of housing and feeding them. Before the stores are one year old (i.e. 5 to 6 cwt. live weight, but the weight may be as low as 4 cwt. in the case of Jerseys) they should receive up to 8 lb. of hay in the ration, rather than all straw, to provide roughage, and roots, if available, may be fed up to 15 lb. daily. Experience shows that young stock thrive particularly well on silage, and their coats carry a characteristic bloom when even small quantities, e.g. 5 to 15 lb. are fed. In these cases the quantity of concentrates fed will rarely, if ever, exceed 4 lb. daily and will consist primarily of 2 lb. of high protein cake, e.g. decorticated ground-nut cake, with or without up to 2 lb. of cheap carbohydrate (cereals or dried sugar-beet pulp according to prices), depending on the quality and quantity of hay being fed.

After the age of one year is reached store cattle may be fed primarily on oat, barley, bean or pea, straw, and given as much as they will eat daily; this may be as much as 30 lb. of straw per day with large hungry stores receiving little food in addition to the straw. Usually pea straw is considered to be more valuable for sheep, but if it is fed to store cattle, in large quantities, they will require only 1 lb. of decorticated ground-nut cake daily to provide them with the requisite protein for maintenance and a little growth; with bean straw 2½ lb. of the same cake will be needed; with oat and barley straw fully 3 lb. of decorticated ground-nut cake will be required. Provided store cattle are given abundant supplies of water they will live quite satisfactorily through a winter on plenty of straw and a small quantity of protein concentrates. If, on the other hand, other feeding-stuffs are available in large quantities, and straw is relatively scarce, then the following rations would be quite satisfactory for

housed store cattle of the following ages and weights, and would provide for about 1 lb. live-weight gain daily.

	Age		
	12 Months	18 Months	24 Months
Live Weight (cwt.)	5	7	9
Poor meadow hay (lb.)	12	16	20
Mangolds (lb.) or	30	30	40
Dried sugar-beet pulp (lb.)	3	3	4
Dec. ground-nut cake (lb.)	2	2	2

Some breeders like to feed silage to store cattle and for comparative purposes some silage is included in the following rations.

	Age		
	12 Months	18 Months	24 Months
Live weight (cwt.)	5	7	9
Poor meadow hay (lb.)	8	12	16
Oat and tare silage (lb.)	10	15	20
Dried sugar-beet pulp (lb.)	3	3	2
Dec. ground-nut cake (lb.)	$1\frac{3}{4}$	$1\frac{3}{4}$	$1\frac{1}{4}$

Some farmers who are drying young grass may think rations should be given here showing the use of dried grass for store cattle, but there is no doubt that the better qualities of such food can be best used for feeding to other stock and so no examples are given.

It should be made quite clear that it is unnecessary to feed dairy heifers food extra to one of the store rations given above, either when they are about to be served (there is no necessity to "flush" as is commonly practised with sheep) or for the first few months after service. Rarely is it necessary to feed special rations to dairy heifers till two or three months before calving is expected; an exception to this statement must be made in the case of a pregnant heifer which starts losing condition on her store ration; then it may be necessary to feed her on a special diet which is slightly more nutritious and palatable than the average rations usually given.

X

FEEDING DAIRY COWS

Pregnant Cows (heifers are included with cows unless specially mentioned).

PREGNANT cows should be dry for 6 to 8 weeks before calving is due and if at that time they are still milking they should be dried immediately so that milk disappears from their udders; till this has taken place it is impossible to prepare them for their next lactations. Cows must be fed well during the last two months of pregnancy because they must replace body tissues lost during their previous lactations; also heifers, in calf for the first time, must be well fed because they are still making skeletal growths. Both of these kinds of pregnant cattle must, in addition, build up body reserves in preparation for their forthcoming lactations. This does not mean that these stock are to be fattened, as for killing, but that they should be covered with a fair amount of flesh as a reserve supply of food which may be called upon after calving. Feeding in preparation for calving has become known popularly as "steaming up"; this consists of giving concentrates in addition to the maintenance ration. At this time the foetus is making certain demands on its dam daily, but these are not very great, being only at most the nutrients equivalent to those necessary to produce 1 gal. of milk. The quantity of concentrates fed is very variable, being from none up to 20 lb. daily, but this will depend on costs of foods in any season and upon the anticipated ability of the cow to milk freely. Some readers may think that this last figure is high but practical experience not only shows that cows will eat this quantity but that they will pay for such feeding by the increase in the subsequent lactation. During some periods of the year, namely early in spring and sometimes when there is a good aftermath after a hay cut, the grass may provide sufficient nutrients to make it unnecessary to give pregnant dairy cows any concentrates. Occasionally a cow naturally carries a lot of flesh towards the end of her lactation and in her dry period; it will not only be wasteful to feed concentrates to such a cow but it would be harmful because it might

increase the difficulty of calving by making the cow too fat. Some cows have long dry periods during which they usually gain condition and do not require concentrated foods. To ensure they receive the best attention all dry cows and heifers should be placed in the charge of the cowman, and, for convenience, should live with the milking cows; this results in the cowman seeing these pregnant stock once, and usually twice daily, and he can see they receive their concentrates. Each animal should be fed as an individual, the quantity of concentrates depending on the condition of each beast. If a cow, or heifer, is in poor condition, it is desirable to feed her generously, i.e. 10 to 20 lb. of concentrates daily as soon as she is dry; the actual quantity should be increased so that the maximum daily ration is reached about a month before calving, then this quantity is maintained until the cow, or heifer, goes "off feed" at calving time.

Nothing has, so far, been said regarding the mixture of concentrates that should be given. Experience shows that the best policy is to feed the same mixture of concentrates to pregnant stock as that they will receive shortly after calving; this is because some cows are difficult to feed after calving and this trouble is accentuated if a change is made in the concentrated ration. Most difficulty will be experienced after calving if completely different foods are given because new foods are not usually taken readily. During pregnancy minerals are as necessary as during lactation and they should be given mixed into the ration or in a salt lick, depending on the system of supplying minerals in use at the time. If cows are running at grass and are not brought into the milking shed for their concentrates a very mealy ration may blow in the wind and so be wasted; in such a case a slight change may be necessary to include a greater proportion of cakes or of cubes in the ration; this may lead to difficulties after calving and usually in such cases as these the simplest thing to do is to feed balanced cubes both before and after calving.

The maintenance ration is usually much the same as for dairy cows, namely grass and green-soiling crops during the summer, and roughages and succulents during the winter. Several slight economies are possible with cows that have long dry periods and also with all cows to a short time before calving, thus in summer they may be put on either second-rate grass or follow behind the main herd; in winter they may be fed on either hay of poorer quality or possibly instead straw and a little cake to provide the necessary proteins. The actual procedure at a farm must depend on the food supplies available and must vary from year to year in accordance with prices.

As the time of calving approaches the quality of the maintenance ration should be improved so that straw is omitted from the ration and only good hay is given. It may be necessary to reduce the quality of hay consumed if the animal shows any signs of constipation, or the quantity of succulents fed may be increased to produce a natural laxative effect on the bowels. If by any chance the pregnant animal is grazing apart from the dairy cows it is quite a common practice to put her with the cows that are in milk, on the better pastures, for at least the last month of pregnancy.

Although it may, at first sight, appear to be irrelevant, it is necessary to discuss some phases of the vital question of milking before calving. When a cow, which naturally milks very freely, during lactation, is being fed concentrates in large quantities prior to calving she may fill her udder several days, and occasionally a week or more, before calving is due. In such cases some farmers consider it is essential to milk her before calving to reduce the risk of damaging her udder permanently by failing to reduce udder pressure. Of course the first milk obtained is colostrum and then normal milk is produced which can be sold for human consumption. It will be observed that one effect will be that the calf will not receive any colostrum. Opinions are divided, but it is suggested that milking before calving leads to delayed calving and possibly difficult calving; if this is really true these are two important points against milking before calving. There can be no doubt that milking during what should be the dry period is bad in that it does not allow the cow to store up reserves and so prepare for lactation; the milk being produced either at the expense of body tissue or from the concentrates being fed. Thus milking during the dry period counteracts the possible advantages that should be derived from the dry period.

Feeding Dairy Cows in Milk (Heifers are included unless specially mentioned).

Whenever a heifer or dairy cow calves at pasture during the summer, feeding is quite simple, for a cow merely eats grass for the first few days after calving till the calf is weaned and the cow enters the milking herd. If the cow calves inside during the summer, or winter, she will be housed for a time, during which period feeding is usually difficult. It is desirable to feed succulent foods to keep the bowels open naturally; the actual foods will depend on the locality and in some cases the actual month of the year, e.g. lucerne from May

to early September, kale from August to March, mangolds from January to May, and grass during the summer; silage may be available for feeding at any time throughout the year. For the first few days after calving, and in order to reduce the natural tendency towards constipation, it is essential to keep the quantity of hay fed as low as possible, i.e. below the normal amount; it is important, however, to watch the particular cow to see that she does not eat her bedding because that may counteract the effect produced by restricting the quantity of roughage fed as hay. If a cow eats her bedding the quantity of hay given should be increased because, for freshly calved cows, hay is a more desirable food than straw. In general no concentrates should be fed during the first three or four days after calving because there is the danger of forcing milk production at a time when the cow's system is unable to stand the strain that is involved. Then swelling is quite common in the udder and feeding of concentrates stimulates milk production and impedes efficient massage, which is essential to disperse inflammation or swelling of the udder. It is quite evident that a cow is underfed just after calving, because she is not given sufficient food for maintenance and production even if her actual milk yield is low; thus it is necessary for the cow to calve down in excellent condition, not only to provide for reserves when milk production is well under way but to provide for the period of underfeeding immediately after calving. It is also necessary to provide a reserve in the event of a difficult calving, and for the cow, in consequence, being underfed for several days after calving. Whenever a cow has had a difficult calving, or the afterbirth is retained for an abnormally long period, feeding is always difficult for a time. Such a cow is an invalid and must be tempted to eat dainty morsels of food and so, by skilful feeding, coaxed back to normal rations; in this case natural succulents will be particularly beneficial.

Many low-yielding cows are given a normal balanced mixture of concentrated foods as soon as they will eat it, which is usually a few days after calving, but very rarely will such cows eat sufficient nutrients to provide for the amount of milk they are producing. With high-yielding cows the feeding is more difficult but in no case will the cows be fed concentrates commensurate with production, with the result that cows must "milk off their backs," i.e. they must draw on body tissues for milk production and in consequence they will lose the condition, or flesh, that has been stored during the dry period. There is no known safe way of feeding a good dairy cow for the first few weeks after calving, to ensure that she does not "milk off her back." At this time great care must be exercised with

the feeding to reduce the loss of body tissues to the minimum but wastage of them cannot be avoided especially when cows are milking freely.

Winter Feeding. At this stage it will be convenient to isolate winter from summer milk production and feeding for the former will be discussed first. In no district in this country is the grass, in winter time, sufficiently abundant and nutritious to provide enough starch and proteins for maintenance purposes; usually the grassland is little more than an exercising ground. The main factors that will decide whether a herd will remain entirely out at grass, lie in at nights only, or remain entirely housed, will be, breed of cow, climate of locality, food and litter supply, the soil, housing accommodation, level of production of the cows, and the preference of the breeder and his men. Whether the cows are housed or at grass, essentially the same concentrated foods can be fed in winter irrespective of where the cows are being kept. For the purpose of considering the question of maintenance rations cows must be divided into three categories according to milk production namely, (*a*) low producers, i.e. cows giving under 2 gal. daily, (*b*) medium producers, i.e. cows giving between 2 and 5 gal. daily, and (*c*) high producers, i.e. cows giving over 5 gal. daily; these figures are given merely as rough yields being rather high for heifers of all breeds and also for mature yields of the smaller breeds, e.g. Jerseys, Kerrys and Dexters. Taking the medium producers first, experimental work that has been carried out at several centres has shown that some succulent foods can, with advantage, be included in all dairy rations because the succulents stimulate milk production. Thirty and forty years ago it was the custom to feed vast quantities of roots to dairy cows but this is uneconomical since feeding large quantities of roots fails to stimulate milk production and actually retards it. For most dairy cows the optimum quantity of roots that should be fed daily seems to lie around 40 lb. of mangolds, and when kale is fed as a root the figure may fall to as low as 30 lb. in view of the richness of the latter crop. It must not be forgotten, however, that mangolds are considered unsafe for feeding till after Christmas on account of their amide content. Thus as it is essential to feed some other kind of "root" before Christmas such as sugar-beet tops, kale, swedes, or dried sugar-beet pulp, which may be used till mangolds are safe for feeding. Fortunately swedes have much the same analysis as mangolds; thus for practical purposes they are interchangeable except that swedes are liable to cause a taint in milk whereas mangolds do not.

If by any chance silage is available it can be fed at about 20 lb.

per head daily. When no home-grown succulents are available some farmers feed moistened dried sugar-beet pulp (4 to 5 lb. of dried pulp per cow) which has the reputation of stimulating milk production in much the same way that roots do. Farmers situated near to distilleries and breweries may buy wet grains and feed them to cows since they stimulate milk production, there is, however, a temptation to feed them too freely to cows. Where the low-yielding cows are involved the quantities of succulents fed may be as above, but if supplies are limited these animals may not receive quite such a large quantity because their respective milk yields being lower will not warrant it. Because higher-yielding cows must consume large quantities of concentrates for milk production purposes, it often follows that so much space is taken up by the essential concentrates in the digestive tract that there is insufficient space left for the normal quantities of succulent foods; thus for high-yielding cows the average quantity of succulents may have to be reduced so much that they may be fed either in subnormal amounts or in some cases omitted from the ration. With high-yielding cows succulent foods are not so essential for keeping the bowels in the right condition because they must eat large amounts of concentrates which are frequently inclined to be laxative when fed in fairly large quantities. Specimen rations are shown in Table I, where it will be seen that rations B, E and G are suitable for cows producing moderate quantities of milk; for low-yielding cows D, F and J must be used whilst for high-yielding cows an example is given later. Costs must be considered; it will be observed from the table that the dearest ration in 1934–5 winter (Ration A) was the 6th dearest in the winter of 1937–8. It is essential, therefore, for a successful feeder to calculate which are the best rations to use in a particular season in view of current prices and food supplies. The method by which maintenance rations are calculated may be explained briefly by taking ration B.

Theoretical requirements for an 11-cwt. cow	S.E.	P.E.
	6·9 lb.	0·74 lb.
Ration B.		
12 lb. Medium meadow hay	4·63 ,,	0·55 ,,
40 lb. Mangolds	2·52 ,,	0·16 ,,
Total	7·15 lb.	0·71 lb.

TABLE I

COMPARATIVE COSTS OF MAINTENANCE RATIONS FOR TWO WINTERS FOR COWS OF 10–11 CWT.

Letter	Ration (Daily)	Total consumed in Winter (180 days)	Winter 1934–35 Cost of Ingredients	Winter 1934–35 Cost of Ration	Winter 1937–38 Cost of Ingredients	Winter 1937–38 Cost of Ration
		tons cwt.	£ s. d.	£ s. d.	£ s. d.	£ s. d.
A	20 lb. Medium meadow hay	1 12	8 0 0	8 0 0	4 16 0	4 16 0
B	12 lb. Medium meadow hay	1 0	5 0 0	6 18 5	3 0 0	4 18 5
	40 lb. Roots	3 4	1 18 5	—	1 18 5	—
C	7 lb. Medium meadow hay	11	2 15 0	—	1 13 0	—
	40 lb. Roots	3 4	1 18 5	6 2 5	1 18 5	4 16 5
	7 lb. Straw (oat and barley)	11	1 2 0	—	16 6	—
	½ lb. Dec. ground-nut cake ..	1	7 0	—	8 6	—
D	21 lb. Straw (oat and barley)	1 13	3 6 0	—	2 9 6	—
	20 lb. Roots	1 12	19 3	4 19 3	19 3	4 5 9
	1½ lb. Dec. ground-nut cake	2	14 0	—	17 0	—
E	12 lb. Medium meadow hay	1 0	5 0 0	7 4 0	3 0 0	5 4 0
	4½ lb. Dried sugar-beet pulp	8	2 4 0	—	2 4 0	—
F	21 lb. Straw (oat and barley)	1 13	3 6 0	—	2 9 6	—
	10 lb. Wet brewers' grains ..	16	1 4 0	5 0 2	1 0 0	4 0 0
	1 lb. Cracked maize ..	1½	10 2	—	10 6	—
G	12 lb. Medium meadow hay	1 0	5 0 0	7 8 0	3 0 0	5 8 0
	20 lb. Oat and tare silage ..	1 12	2 8 0	—	2 8 0	—
H	14 lb. Straw (oat and barley)	1 2	2 4 0	—	1 13 0	—
	25 lb. Oat and tare silage ..	2 0	3 0 0	5 14 2	3 0 0	5 3 6
	1 lb. Cracked maize ..	1½	10 2	—	10 6	—
J	28 lb. Straw (oat and barley)	2 4	4 8 0	5 2 0	3 6 0	4 3 0
	1½ lb. Dec. ground-nut cake	2	14 0	—	17 0	—

N.B. Roots are taken to include mangolds or swedes only.

Since only average analyses of feeding stuffs are used and the requirements of the average animal are given, it may be considered that for all practical purposes the ration supplies the necessary nutrients for the 11-cwt. cow for maintenance.

The cost of this ration for the winter should be assessed in the following way by taking the prices in the winter 1937–8 for hay to be £3 per ton and for mangolds or swedes 12s. per ton.

Taking 12 lb. of hay a day for a winter of 180 days it follows that the amount consumed by a cow during one winter will be $\frac{12 \times 180}{2240}$

which is $\frac{27}{28}$ or about 1 ton, similarly 40 lb. of roots will be $\frac{40 \times 180}{2240}$ which is $\frac{45}{14}$ or about 3 tons 4 cwt., thus the cost of the material used for the winter is:

	£	s.	d.
1 ton of hay at £3 per ton	3	0	0
3 tons 4 cwt. of roots at 12s. per ton	1	18	5
Cost of ration per cow during winter	£4	18	5

The corresponding figure for the winter 1934–5 was £6 18s. 5d.
In Table I the following basic costs per ton were used:

	1934–1935	1937–1938
	£ s. d.	£ s. d.
Medium quality meadow hay	5 0 0	3 0 0
Straw (oat and barley)	2 0 0	1 10 0
Silage (per ton)	1 10 0	1 10 0
Roots (Mangolds or Swedes)	12 0	12 0
Wet brewers' grains	1 10 0	1 5 0
Dried sugar-beet pulp	5 10 0	5 10 0
Decorticated ground-nut cake	7 0 0	8 10 0
Cracked maize	6 15 0	7 0 0

In the above example the complete maintenance rations have been given and hay has been used. For all cows producing between 2 and 5 gal. of milk daily, hay is the best roughage that can be given and it should be of at least medium quality. A rough general guide as to the quantity of hay that can be given to a moderate-producing cow is that she will consume approximately 1 lb. of hay for each 1 cwt. of her live weight provided 40 lb. of roots, or the equivalent, are being fed daily. For low-yielding cows it is possible to give them either poor quality hay or, if hay is scarce, or very expensive, straw may be given together with possibly a little cake to provide the requisite quantity of proteins. The low-yielding, and possibly dry cows, will often eat large quantities of straw to fill their digestive tracts because they may be receiving very small rations of concentrated foods. Dry cows, with long periods to wait before calving, may be fed as much as 30 lb. of straw daily if there is an adequate supply, and hay is wanted for the production of stock.

The high-yielding cows, i.e. those giving in general over 5 gal. daily will require the best quality of hay that is available which is

often best meadow or best seeds hay. The quantity may be considerably below the amount indicated in the table because of the space the heavy feeding of concentrates, that are essential, will occupy in the digestive tract. Some hay is, however, essential, even with the highest-yielding cows, for experience shows that if it is omitted entirely from a ration rumination may be affected and indigestion may ensue. In general the minimum quantity of hay that can be fed daily is 6 lb. to a Shorthorn cow weighing 10 to 14 cwt.

Production rations call for much greater discussion because they are usually the more expensive parts of the ration and it is much easier to make mistakes with them. The richness of the milk influences the nutrients necessary to produce that milk; this is shown by the following figures:

	S.E. (lb.)	P.E. (lb.)
Theoretical requirements for 1 gallon of milk of—		
3·7 *to* 3·8% *B.F.*	2·50	0·60*
5·2 *to* 5·3% *B.F.*	3·25	0·81

* Some authorities give 0·50 lb., but for safety 0·60 lb. will be given.

Fortunately the proportion of starch to protein remains approximately constant at a ratio of 4:1 for all levels of fat production; it therefore follows that it is not necessary to have different mixtures for cows producing milk of different butter-fat contents but merely the quantity of concentrates fed must vary for each gallon of milk. In general if 3½ lb. of a mixture is required to supply the necessary nutrient for one gallon of milk containing 3·7% butter-fat, then 4½ lb. of the same mixture will be required for the necessary nutrients to produce 1 gal. of milk containing 5·2% butter-fat. Thus, though it is very rarely carried out in herds, the high butter-fat producing cows should receive more concentrates for each gallon of milk that is produced than is allowed for low butter-fat cows. In general, in any one herd, all cows of the same breed are given the same quantity of concentrates for each gallon of milk they produce.

It is now necessary to consider suitable mixtures of concentrates for dairy cows—mixtures that will be suitable for dry cows and those in milk. A large variety of rations can be suggested that supply all the nutrients required for milk production but, in general, the most satisfactory mixtures are those that must be fed at rates of 3 to 4½ lb. of concentrates for each gallon of milk produced. It is impossible to calculate a mixture of suitable foods that will supply

all the necessary nutrients when less than 3 lb. are fed daily to dairy cows; if, on the other hand, a mixture contains relatively bulky and poor quality foods resulting in a mixture that must be fed in quantities greater than 4½ lb. daily (and that quantity only for cows giving milk of a high butter-fat content) then the mixture is not sufficiently concentrated and should not be given to cows giving more than about 2 gal. of milk daily. This means that certain foods such as brewers' grains (dried), distillers' grains, malt culms, bran and molasses can be used only in small quantities in any mixtures. Advertisements are frequently displayed in the press recommending the use of bran as a balanced concentrate for dairy cows; it is balanced for milk production but the difficulty lies in the fact that it contains such a small quantity of nutrients that 6 lb. are required to provide the necessary nutrients for 1 gal. of ordinary milk.

The following are the prices of feeding-stuffs used in the calculations in Table II:

Food	Price in the Year	
	1934–35	1937–38
	£ s. d.	£ s. d.
Crushed wheat	5 5 0	9 10 0
Crushed oats	7 10 0	10 10 0
Crushed barley	7 0 0	9 10 0
Cracked maize	6 15 0	7 0 0
Dried sugar-beet pulp	5 10 0	5 10 0
Maize gluten feed	6 10 0	8 10 0
Bran	7 10 0	8 0 0
Cracked beans	8 15 0	9 10 0
Palm kernel cake	7 5 0	7 15 0
Linseed cake	10 0 0	10 10 0
Decorticated ground-nut cake	7 0 0	8 10 0

Table II gives several mixtures of concentrated foods that may be fed as they stand to cows in milk. For low-yielding cows, i.e. giving less than 2 gal. of milk daily it is possible to give the cheapest mixture which is ration No. 5; this was the cheapest ration in both of the seasons shown in Table II. It is, of course, quite obvious that the method of assessing the value of a mixture is not to take its price per ton, but the amount of food contained in that ton must also be considered; thus the cost of the winter's concentrates to produce 370 gal. of milk gives the best figure for comparable purposes. It must be explained that costs will vary from season to season and a mixture that is cheap one year may be relatively dear the next.

No.	Mixture	Lb. needed per gal. of Milk	Lb. Concentrates for 370 gallons	Winter, 1934–35		Winter, 1937–38	
				Price per ton of Mixture	Cost of Concentrates for 370 gallons	Price per ton of Mixture	Cost of Concentrates for 370 gallons
				£ s. d.	£ s. d.	£ s. d.	£ s. d.
1	1 part by weight Crushed oats .. 2 parts ,, ,, Cracked maize .. 2 ,, ,, ,, Cracked beans .. 2 ,, ,, ,, Linseed cake ..	3½	1295	8 10 0	4 18 3	9 4 3	5 6 6
2	3 parts by weight Crushed oats .. 4 ,, ,, ,, Cracked beans ..	3½	1295	8 4 3	4 15 10	9 18 7	5 14 10
3	2 parts by weight Crushed oats .. 2 ,, ,, ,, Crushed barley .. 1 part ,, ,, Crushed wheat .. 2 parts ,, ,, Decorticated ground-nut cake ..	3½	1295	6 18 0	4 0 6	9 10 0	5 9 10
4	1 part by weight Palm kernel cake .. 1 ,, ,, ,, Maize gluten feed ..	3½	1295	6 17 6	4 0 3	8 2 6	4 13 11
5	2 parts by weight Cracked maize .. 2 ,, ,, ,, Dried sugar-beet pulp .. 1 part ,, ,, Crushed wheat .. 2 parts ,, ,, Decorticated ground-nut cake ..	3½	1295	6 5 0	3 13 0	7 7 2	4 5 1
6	2 parts by weight Bran .. 3 ,, ,, ,, Crushed oats .. 2 ,, ,, ,, Linseed cake .. 1 part ,, ,, Cracked beans ..	4	1480	8 5 6	5 10 4	9 15 0	6 8 10
7	2 parts by weight Dried sugar-beet pulp .. 1 part ,, ,, Bran .. 1 ,, ,, ,, Decorticated ground-nut cake ..	4	1480	6 7 6	4 5 0	6 17 6	4 10 10
8	Manufacturer's cakes balanced for milk production ..	3½	1295	7 10 0 8 0 0 8 10 0 9 0 0 9 10 0	4 6 9 4 12 6 4 18 3 5 4 1 5 9 10	7 10 0 8 0 0 8 10 0 9 0 0 9 10 0	4 6 9 4 12 6 4 18 3 5 4 1 5 9 10

Cows should have in addition SALT and MINERALS.

Thus rations must be reviewed at least each year to provide the cheapest mixtures possible. This ration, (No. 5) does not contain sufficient variety for the better-yielding cows and should have another mixture added to it, which could be ration 3 or 4 in 1934–5, or rations 4 or 7 in 1937–8. The modified rations thus become *Ration No.* 9 which consists of:

<table>
<tr><td>Ration No. 5—
2 parts by weight Cracked maize
2 parts by weight Dried sugar-beet pulp
1 part by weight Crushed wheat
2 parts by weight Decorticated ground-nut cake</td><td>3½ lb. per gal.</td><td rowspan="2">3½ lb. per gal.</td></tr>
<tr><td>Ration No. 4—
1¾ parts by weight Palm kernel cake
1¾ parts by weight Maize gluten feed</td><td>3½ lb. per gal.</td></tr>
</table>

This costs £3 12s. 1d. in 1934–5 and £4 8s. 0d. for the winter 1937–8. If, on the other hand, the excess of ration 5 over No. 4 is larger than shown in the example it is obvious that the cost will be reduced because No. 5 is the cheaper ration. Should it be decided that ration No. 7 should be used it is most simple if rations No. 5 and 7 are mixed in equal quantities and then fed at the rate of 3¾ lb. per gal. of milk produced. For higher-yielding cows it is possible, and desirable, to make one further addition to the ration No. 9, namely by adding No. 1, for although it is rather expensive it provides foods that are well known as being good for milk production, e.g. beans, oats and linseed cake. For high-yielding cows it is possible to add rations 1, 4 and 5 and that will give a ration No. 10 balanced for high-yielding cows at the rate of 3½ lb. of concentrates per gal. of milk which will cost for 370 gal. of milk in the winter of 1934–5 £4 2s. 11d. and £4 15s. 5d. in 1937–8. The only possible difficulty that may arise with this ration No. 10 is that it may be rather laxative; if that is the case it may be necessary to add a small quantity of undecorticated cotton cake to the ration, e.g., up to 2 parts. It so happens that with the mixture of concentrates in ration No. 10 the balance is not upset when the cotton cake is added; it is in fact slightly more balanced since each of rations 1 and 5 is very slightly low in proteins and the effect cumulates when the three rations are added together. That the mixture No. 10 with the undecorticated cotton cake added will be palatable to most cows there is no doubt, but in most herds there are usually some difficult cows that demand special rations. Experience shows, however, that usually some balanced mixture can be found that they like although it may be difficult to ascertain; this may be done either by trying each feed

individually before a cow or by trial and error with various mixtures. In this connection a cow may be cited who would never eat a balanced ration of any kind and insisted on being given a ration consisting mainly of crushed oats and sometimes, a little linseed cake added.

For convenience Table II gives the quantities of concentrates to be fed to cows giving from 3·5 to 4·0% of butter-fat content, if cows are giving richer milk the quantity of concentrates fed should be increased to 4½ lb. daily with milk of 5·0 to 5·5% butter-fat, and other variations should be made in proportion.

Some concentrated rations that farmers have given to cows yielding up to 10 gal. of milk are more complicated than ration No. 10; this may be illustrated by the following ration No. 11 and, for the convenience of those who wish to have the method of calculating rations, the food nutrients have been written beside each food.

RATION NO. 11

	S.E., lb.	P.E., lb.	Lysine, gm.
5 lb. Flaked maize	4·20	0·46	7·0
2 lb. Crushed oats	1·20	0·15	4·4
2 lb. Crushed wheat	1·43	0·19	—
3 lb. Cracked beans	1·97	0·59	38·7
3 lb. Palm kernel cake	2·20	0·51	—
2 lb. Bran	1·19	0·20	9·0
1 lb. Linseed cake	0·74	0·25	9·6
1 lb. Decorticated ground-nut cake	0·73	0·41	14·1
2 lb. Undecorticated cotton cake	0·80	0·30	—
½ lb. Decorticated cotton cake (Egyptian)	0·34	0·17	6·2
½ lb. Meat meal	0·46	0·33	21·4
22 lb. contain	15·26	3·56	—
1 lb. contains	0·694	0·162	—
3½ lb. contain	2·429	0·567	—
3¾ lb. contain	2·602	0·607	—

Theoretical requirement for 1 gal. of milk containing 3·5 to 4·0% of butter-fat is 2·50 lb. S.E. and 0·60 lb. P.E. therefore 3½ to 3¾ lb. of the above mixture will provide the theoretical requirements for 1 gal. of ordinary milk.

The importance of the use of sound foods, of freshly ground or crushed foods (i.e. avoiding those that have heated after crushing) and of the right mixing of the foods cannot be over-emphasized; high-yielding cows easily go "off feed" and if they do so with a ration they have been eating it will be frequently be because of one of the above points.

Experience shows that from many aspects proprietary balanced cubes are sound foods to use (if obtained from a reliable firm)—they are very palatable—they have no bad effects on bowels—they are easy to handle and feed—they require no skill in compounding and mixing rations on a farm and they usually contain an adequate supply of minerals. Where a small herd of cows is kept, where cows are the only kind of stock on any grassland farm growing no cereals, or where high yields are obtained and a specially good ration is required to supply ½ to ⅓ of the concentrates fed, there is no doubt a strong case for the use of purchased balanced concentrates for dairy cows. Where little or no home-grown foods are available it is expensive to buy large quantities of concentrates (and it is necessary to buy 5-ton lots of the various ingredients of a ration if low prices are to be paid), thus much money is expended and there is the danger that foods may deteriorate with storage. It is only on the large farms where several kinds of stock are kept and where some home-grown concentrates are available that mixing on the farm is worth while, unless a very large herd has to be catered for. For the benefit of those wishing to compound their own balanced milk mixtures, a simplified system of calculation is given on page 65.

Some farmers are apt to forget that the purchased balanced cubes are balanced, and that the feeding of additional quantities of cereals is a mistake for the balance is upset, for the cereals do not supply sufficient proteins. It is possible to purchase cubes to be used in conjunction with a certain proportion of cereals; some farmers find the use of these cubes to be a sound proposition.

Since the above has been written recently published research work suggests that the 4:1 ratio of starch to protein equivalents may provide a little more protein than is really required by milking-cows. While this may be true for lower milking cows some authorities are very dubious whether it can be safely recommended in two cases, namely where milk yields are high and secondly where maintenance rations are of doubtful value. With high-yielding cows (i.e. for cows giving more than 5 gal. per day) previous experimental work has suggested that more protein is required than provided by the 4:1 ratio and that increased yields may be obtained if the ratio is nearer 3:1; thus one hesitates to advise the adoption of a 5:1 ratio for such high-yielding cows. On many farms there is a tendency for farmers to over-estimate the value of the hay they feed to cows; because of this it seems to be dangerous to recommend a general reduction in the protein content of the production rations.

The revised basis applies to milk of all butter-fat percentages; for standard milk of 3·5 to 4% butter-fat 2·50 lb. of S.E. and only 0·50 lb. of P.E. are needed. It is essential for students, however, to be *au fait* with recent developments, the rations shown in Table II on page 194 are modified to meet the new ratio of 5:1 and given in Table III. As would be expected the new rations are made by increasing the proportion of cereals included. In general protein foods are imported and they are relatively expensive, thus the new rations usually will be cheaper than those calculated on the old basis.

Effects of Foods on Milk Composition. Attention should now be directed to the other factors that must be considered in the dairy ration, namely, the possible effect on butter-fat, solids-not-fat production, the biological value of the protein present and also the mineral content.

Taking first the effects of feeding-stuffs on the output of butter-fat. Authorities differ on the subject, some state that no feeding that does not reduce yield will have any beneficial effect on butter-fat production and yield, whilst others state, supported by experimental evidence, that the feeding of certain fats and oils may stimulate butter-fat production without changing milk yield. There seems to be some evidence that the following oils may increase the butter-fat percentage in cows' milk, and also that the increase is most marked in the breeds that ordinarily produce the richer milk (Jerseys and Guernseys): palm oil, cotton-seed oil, linseed oil, butter and possibly such animal fats as lard and dripping. It has also been suggested that rations consisting of the various cakes which naturally contain the above oils may increase butter-fat content (this is firmly believed in some countries in northern Europe). It is more generally accepted that the addition of even a small quantity of cod-liver oil (a daily ration of 3 oz. of the oil) to a cow's ration will reduce the butter-fat content of her milk quite markedly; there is also some suggestion that whale oil may have a similar effect. Some foods that stimulate milk production and which do not stimulate butter-fat production will have the effect of reducing the butter-fat percentage in the milk, such foods are brewers' grains, moistened dried sugar-beet pulp and, occasionally, a heavy root ration.

In some countries, though not to any extent in this, attention must be paid to the effects foods have on the quality or nature of the butter-fat. The following oils when fed as oils, as cakes, or as meals, produce hard and brittle butter; cotton-seed oil and coco-nut oil, and large quantities of wheat and barley in rations may also produce similar effects. Linseed and soya bean and occasionally

TABLE III

COMPARATIVE COSTS OF PRODUCTION RATIONS, 1937–38 FOR COWS GIVING MILK CONTAINING 3·5–4% BUTTER FAT. REVISED RATIO 5 : 1

No.	Mixture	Lb. needed per Gallon of Milk	Lb. Concentrates for 370 gallons	Price per ton of Mixture	Cost of Concentrates for 370 gallons
				£ s. d.	£ s. d.
1a	1 part by weight Crushed oats . . . . 2 parts by weight Cracked maize . . . . . . 1 part ,, ,, Cracked beans . . . . 1 ,, ,, ,, Linseed cake	3½	1295	8 18 0	5 3 5
2a	6 parts by weight Crushed oats . . . . 4 ,, ,, ,, Cracked beans	4	1480	10 2 0	6 13 11
3a	2 parts by weight Crushed oats . . . . 2 ,, ,, ,, Crushed barley . . . . . . 1 part ,, ,, Crushed wheat . . . . . . 1½ parts ,, Decorticated ground-nut cake . .	3½	1295	9 11 7	5 11 6
4a	1 part by weight Palm kernel cake . . . . . . 1 ,, ,, ,, Maize gluten feed . . . . . . 1 ,, ,, ,, Crushed barley	3½	1295	8 11 8	4 19 10
5a	3 parts by weight Cracked maize . . . . . . 3 ,, ,, ,, Dried sugar-beet pulp . . . . 2 ,, ,, ,, Crushed wheat . . . . . . 2 ,, ,, ,, Decorticated ground-nut cake . .	3½	1295	7 7 0	4 0 8
6a	2 parts by weight Bran . . . . 5 ,, ,, ,, Crushed oats . . . . 1 part ,, ,, Linseed cake . . . . 1 ,, ,, ,, Cracked beans	4	1480	9 16 8	6 10 4
7a	2 parts by weight Dried sugar-beet pulp . . . . 1 part ,, ,, Bran . . . . ½ ,, ,, ,, Decorticated ground-nut cake . .	4	1480	6 13 10	4 8 1

maize products, on the other hand, when fed in excess, produce a soft oily fat in butter. It has also been observed that there are definite breed differences; foods that influence the type or nature of butter-fat in the case of cows of one breed do not necessarily do so to the same degree with cows of another breed.

Of the various features that may influence the solids-not-fat content of milk little is really known at the present time. Milk of low solids-not-fat content is usually obtained from the breeds that ordinarily produce milk of low butter-fat content, and observations show this is more likely to occur during the summer rather than during the winter-feeding period, and more especially at time of drought when the pasture is not very productive. No concentrated foods are known to stimulate the production of solids-not-fat and succulents, fed at times of drought, are the only foods that have been considered likely to influence the output.

Turning to the nature of proteins it must be readily admitted that science has not advanced sufficiently far to state the exact requirements of dairy cows for the various amino acids. It is known that certain amino acids are essential for normal healthy growth but the quantity required, the quantity present in the various foods and also the effect of feeding mixed diets on their utilization, is not known. The accepted way of describing the amino acids in a food is not to state each present but to give the biological value of the food which describes its real food value very succinctly. Work that has been carried out so far suggests that for milk production the following list is the order of biological values of the foods:

	Biological value.
Fresh dried spring grass Grass silage (from summer grass) Lower-temperature dried blood meal	75–80%
Fresh dried autumn grass Bean and pea meals	60–65%
High-temperature dried blood meal Meat meal	55–60%
Decorticated ground-nut cake Flaked maize	50–55%
Linseed cake	45–50%

Unfortunately all the common feeding stuffs have not been studied, but the above list serves to show (well known to practical men) that beans may have a value above that of ordinary S.E. and P.E. content. Another possible way of considering this question is to study lysine content of the production ration for one authority writes that 17 gr. of lysine are essential for each 1 gal. of milk produced. The ration No. 11 (page 196) provides more than that

amount per gal. of milk produced (although figures are not available for some foods) and may account for the efficiency of this ration in practice for high-yielding cows. It is of course the latter cows that are most likely to suffer from amino acid deficiencies and it is known that with laboratory animals (rats) the effects are not produced immediately, but rather after periods of continued malnutrition. It is just possible that such difficulties as breeding troubles, and lack of resistance to disease, may be to some extent related to amino-acid deficiencies.

Turning to minerals it must of course be recognized that the mineral content of foods is very much influenced by the mineral content of the soil on which they are grown, and that foods are exceedingly variable regarding the quantity of minerals they contain. For maintenance purposes a cow of average weight should receive 0·094 lb. of lime (CaO) and 0·050 lb. of phosphoric acid (P_2O_5) daily; the maintenance ration, e.g. B (page 190), will supply plenty of these minerals—

	CaO	P_2O_5
	lb.	lb.
12 lb. Medium quality meadow hay	·120	·052
40 lb. Mangolds	·008	·036
Total	0·128	0·088

In actual fact all ordinary balanced rations will provide the requisite amounts of calcium and phosphorus for maintenance purposes together with a small surplus. For production about 0·040 lb. of lime (authorities differ a little) and about 0·050 lb. of P_2O_5 are required for a gallon of milk. Taking rations Nos. 4 and 5 (page 194) it will be seen that the ration gives very little of the essential minerals:

RATION NO. 5

	CaO.	P_2O_5
	lb.	lb.
2 lb. Cracked maize	·0004	·0164
2 lb. Dried sugar-beet pulp	·0240	·0036
1 lb. Crushed wheat	·0005	·0086
2 lb. Decorticated ground-nut cake	·0040	·0260
7 lb., i.e., for 2 gallons	·0289	·0546
3½ lb., i.e., for 1 gallon	·0144	·0273

RATION NO. 4

	CaO	P_2O_5
	lb.	lb.
1 lb. Maize gluten feed	·0010	·0070
1 lb. Palm kernel cake	·0030	·0110
2 lb. mixture	·0040	·0180
3½ lb. of mixture (i.e. for 1 gallon of milk)	·0070	·0315

It will be observed that neither of these rations provides sufficient calcium or phosphorus for milk production; a little surplus will be obtained from the maintenance ration for cows giving low yields of milk, but all giving over 2 gal. must receive some of these minerals from another source. For the most efficient utilization that source must be of animal or vegetable origin in preference to pure mineral source; sterilized steamed-bone flour is an obvious choice. Usually some 2% of a balanced mixture should consist of this mineral food; when such a quantity is fed then 0·032 lb. of CaO and 0·022 lb of P_2O_5 will be supplied for each gallon of milk produced. This will supply all the minerals that are required for milk production with the possible exception of salt. No known requirements of salt are available and there is evidence that requirements seem to depend on the individual palates of animals and so no amount can be prescribed. It is recommended that rock salt should be made available for stock to lick at will, rather than salt be added to a balanced ration; this prevents stock from taking salt in amounts they wish and it is not recommended.

There is yet one further aspect of winter feeding of dairy cows that must be considered and that is its bulk, or space, occupied inside the animal's body. Many authorities state that a cow can consume 33 lb. of dry matter a day, but it seems that a better way of stating the case is to say that dairy cows will, on the average, consume 3 lb. of dry matter for each 1-cwt. of live weight. Experience shows that very high-yielding cows may have unusually large digestive tracts, and they may be able to consume more than this expected amount of dry matter per unit of live weight. This average figure is only to be taken as a rough guide as also may the fact that concenrated foods and hay are about ⅛ water and succulents are at least ⅚; with these figures in mind it is possible to estimate the bulk of a ration quite easily. Taking a 10-cwt. cow Table IV shows how the feeding must vary with increasing yields, although of course the capacity remains more or less fixed at 30 lb. of dry matter. If ration B (12 lb. hay and 40 lb. of mangolds) is taken from Table I

(page 190) it may be shown that this ration contains 15·56 lb. D.M. and if a normal mixture of concentrates, e.g. No. 5 (page 194), is taken for production Table IV holds:

TABLE IV
POUNDS OF DRY MATTER FED WITH VARIOUS MILK YIELDS

Rations used	Maintenance and						
	0 gal. milk	1 gal. milk	2 gals. milk	3 gals. milk	4 gals. milk	5 gals. milk	6 gals. milk
B and 5, containing 15·56 lb. D.M. for maintenance, plus 3·10 *lb. D.M.* for each gallon of milk	15·56	18·66	21·76	24·86	27·96	31·06	34·16
J. and 5, containing 25·20 lb. D.M. for maintenance, plus 3·10 *lb. D.M.* for each gallon of milk	25·20	28·30	31·40	34·50	37·60	40·70	43·80

From the above table it is quite obvious the first scheme is suitable for a cow yielding 4 to 6 gal. of milk because for the lower yields the cows would not be filled sufficiently, and would, in all probability, eat their bedding. In the second case the ration is so bulky that it is useless for yields of over 3 gal. of milk daily. This simple table demonstrates the necessity of having different maintenance rations for cows producing different quantities of milk. In many herds, and especially where stock lie in yards all winter, it is the custom to supply long straw (oat or barley) so that any cows that may be hungry may fill themselves with straw after they have had their normal ration; this allows for variations in appetites and prevents stock from eating bedding, which is not only poor food in itself, but frequently carries infections.

In the case of cows giving 8 or 10 gal. of milk daily, the quantity of hay fed will fall to 6 lb., the roots will often be fed as dried sugar-beet pulp and then some 36 lb. of concentrates may be given; this total ration supplies some 35–40 lb. of dry matter, of which over 30 lb. is from the concentrates. It is quite obvious that only a relatively large cow can eat sufficient food to enable her to give big milk yields.

This question of bulk plays a big part in attempts that are made to feed cows on dried grass; one of the problems that is frequently overlooked in connection with dried grass is that it is exceedingly

bulky. There is no doubt that good dried grass is more suitable for feeding to dairy cows than to any other farm animals. It must be fully recognized, however, that dried grass is a very variable product, sometimes being a concentrated food and at others being only equivalent to good quality hay. Quality is assessed mainly upon the chemical analysis for crude protein, and samples of dried grass that contain 18% or more of crude protein are called best quality, 4 lb. being thought to be equivalent in food value to 3·5 lb. of balanced dairy cakes. The second quality dried grass contains 15·00 to 17·99% (inclusive) of crude protein and 6 lb. are taken to be equivalent to 3½ lb. of balanced concentrates together with 3 lb. of hay. Whilst the dried grass that contains 12·00 to 14·99% of crude protein is called super hay and 4 lb. are equivalent in food value to 6 lb. of average quality meadow hay. Although the traders make no mention of the differences that exist between grass cut and dried in spring, and that cut and dried in the autumn, practical experience shows that the spring grass is more palatable, even if samples cut at these two times have approximately the same chemical composition. Table V gives a system of feeding dried grass that some practical men have adhered to for average cows of about 10 cwt. live weight.

TABLE V

DAILY RATIONS IN POUNDS USING VARIOUS QUALITIES OF DRIED GRASS

Quality of dried grass used	Food used	Daily Rations (lb.) for Yield in Gallons					
		0	1	2	3	4	5
Best quality	Dried grass Hay	— 20	4 20	8 20	12 18	16 14	20 10
Medium quality	Dried grass Hay	— 20	6 17	12 14	18 11	24 8	— —
Super hay	Super hay Hay	— 20	20 —	30 —	— —	— —	— —

Theoretically it would appear that 6 gal. of milk could be obtained by feeding 24 lb. of best quality dried grass and 6 lb. of hay, but in practice, the difficulty would arise that it takes a very long time for the 6 gal. cow to eat her 24 lb. of dried grass. Medium quality dried grass is only suitable for medium-producing cows whilst super hay can be fed only to low yielding and dry cows. In practice it is found that cows that are used to receiving ordinary concentrates do

not always like dried grass, and great difficulty may be experienced in persuading them to eat it in preference to ordinary balanced mixtures of concentrates. In one experiment in which the writers were concerned some cows could eat only 2 to 3 lb. daily of best quality dried grass (which actually by analysis contained 19 to 20% crude protein) whilst a few cows, especially low-yielding ones, consumed as much dried grass as was given them. The authors doubt, however, if cows will eat 20 lb. of dried grass unless they are starved to the ration, or have been given dried grass both before and after calving.

Summer Feeding of Dairy Cows. Feeding of dairy cows is exceedingly difficult during the summer season because grass forms the major part of cows' rations and that varies considerably in food value from field to field, from season to season, and also throughout a season. It is possible to take samples of grass from a field, to analyse it and to find its chemical composition, but the next difficulty lies in the fact that one does not know how much grass a grazing cow will eat each day. During the winter it is possible to control feeding very carefully, and to measure or weigh the foods given, but in the summer, control of consumption is only possible by restricting the time allowed for feeding; a wise animal will merely eat more during the grazing period, and so tend to defeat one. The only possible way of feeding is to watch the condition of the cows, their milk yields, and to build up experience, on a particular farm, of the food value of the grassland. When cows are first turned out to pasture in spring the grass is young and usually very nutritious and makes the stock scour. To counteract this it is possible to (*a*), feed a small quantity of undecorticated cotton cake (*b*), feed a ration of hay to the stock each morning after milking and before turning out to grass (*c*), limit the time allowed for grazing by starting with a few hours and increasing the time as the stock become accustomed to the grass.

In early spring young grass is very rich in protein and by experience some farmers know that cows grazing freely on such grass may obtain all the nutrients for maintenance and for the production of 2½ gal. of milk daily. This is not the full story, for there is sufficient protein for a further 1½ gal. of milk and only starchy foods should be supplied for that 1½ gal. of milk. A simple way of supplying that small amount of starch equivalent is to give a mixture of carbohydrate foods consisting of home-grown cereals or, if they are not available, flaked maize or dried sugar-beet pulp. Carbohydrate concentrates may be fed at the rate of 4 lb. of mixture for each gallon

of milk produced over 2½ gal. till 4 gal. is reached. If by any chance any cows are giving more than 4 gal. of milk daily, then balanced concentrates must be given for all yields over 4 gal. If a cow is yielding much over 6 gal. daily experience shows that she must eat more grass (which is a bulky food) to provide for the level of milk that is produced than her capacity permits; thus her milk yield falls to about the 6 gal. mark, unless her time for grazing is restricted to a few hours a day, and she may have to be fed very largely on winter rations. Whether it is a sound financial proposition to have such high-yielding cows that they cannot eat grass during the summer but must be housed instead to be fed winter rations is hardly a question to be discussed here. The feeding at the beginning of the grazing season may be represented in Table VI.

TABLE VI

DAILY RATIONS FOR VARIOUS LEVELS OF PRODUCTION FOR COWS GRAZING IN EARLY SPRING

Food	Maintenance and Production of Milk in gallons						
	0	1	2	3	4	5	6
Grass	←			*ad lib.*			→
Carbohydrates mixture (lb.)	—	—	—	2	6	6	6
Balanced concentrates (lb.)	—	—	—	—	—	3½	7

As the season advances the carbohydrates and the balanced concentrates are fed at lower levels of production and, in some districts, by mid-June, the grass may only provide sufficient nutrients for maintenance purposes, whilst still later in the season, and especially if there is a drought, the grass may need supplementing with succulent foods or with hay before it will provide even maintenance rations. In some seasons when rainfall is high, or in districts where there is always plenty of rain, provided grazing is well managed so that young grass is available, it is possible for cows to obtain maintenance and possibly the first gallon of milk from the grass throughout the whole season and even in early autumn. The only way to feed cows during the summer period is to watch their condition carefully and to watch milk yields carefully; to do this, milk recording is essential.

Throughout the summer salt should always be available either as rock salt or with minerals added, the latter may be essential for cows receiving no concentrates, as a means of ensuring that they

receive adequate supplies of the essential minerals. When any concentrates are being fed the minerals should be added in just the same way as for winter feeding.

Although mention has already been made of the foods that may be used for green-soiling it may be worth while repeating that foods may be fed during the months indicated in Table VII.

TABLE VII

FOODS FOR GREEN-SOILING TO DAIRY COWS

Month	Foods
June	Seeds, Oats and Tares, Lucerne
July	Seeds, Oats and Tares, Lucerne and Cabbages
August ..	Aftermath seeds, Lucerne, Spring-sown Oats and Tares, Maize, Early-sown Kale, Cabbages
September ..	Aftermath seeds, Lucerne (in early part of month), Maize, Kale, Cabbage, Kohl rabi.
October ..	Kale, Kohl rabi, Cabbages, Swedes, Sugar-beet Tops

All of the foods in Table VII should be fed to the stock on the pastures because indoor feeding is so wasteful unless the foods are given chopped up. The quantities fed per day will depend on the growth of the grass and the supply of succulents, but usually up to 25 lb. of the given foods may be fed daily to average-sized cows.

XI

FEEDING FATTENING CATTLE

SINCE cattle may be fattened at various ages it is first necessary to describe the chief kinds of meat that can be obtained from them. Calves are killed for human consumption when they are not more than three months of age, and weigh 250 to 300 lb., depending on breed; the meat from these calves is known as veal and is produced from dairy and dual purpose parents. The second class of cattle is killed at about 15 months of age and produces baby beef, at weights varying from 6 to 9 cwt. with a mean between 7 and 8; baby beef is produced primarily from the dual purpose breeds of cattle. Beeflings are killed at 18 to 24 months of age when they weigh 8 to 11 cwt.; these animals will include stock from the dual purpose and pure beef breeds. At the present time mature beef is obtained from cattle that are over the age of 2½ years when killed, these may be as old as 4 years in some rare cases, and will be from beef and dual purpose breeds and will weigh, when killed, anything over 10 cwt. and in very rare cases up to as much as 1 ton. The last class of beef that is produced is cow beef, which is far more common than some realize; one authority estimates that 57% of all English beef consumed in this country is cow beef. This is obtained from females that have calved at least once in either a dairy or a beef herd. Since the life of the dairy cow is short, and in many parts of this country milk production is an important enterprise, it necessarily follows that many cows discarded from the dairy herds, usually those of the dual purpose breeds, are eventually sold for human consumption. Live weights will cover a wide range (9 to 16 cwt.) and ages may vary from about 4 to 10, and in extreme cases up to 20, years. Each class of meat calls for at least one special system of feeding and it is proposed to discuss each class in the order given above.

Veal.

Veal is not as commonly consumed in this country as in many of the European countries, and may be considered more as a luxury than as a normal meat. There is a suggestion that the public demand

veal for a special season, usually in spring and at a time following high prices for milk; in addition to this there is a slight but constant demand for veal throughout the year; it cannot be said, however, that veal is consumed in relatively large quantities in this country. It is commonly stated that the best quality veal is purchased by hotels; for this trade the lean meat must be absolutely white in colour and similar in texture to that found on the breast of a chicken. Rumour has it that chickens of this country produce too many wings and too few breasts and that in some restaurants breast of chicken is augmented by white-fleshed veal. It is not possible to produce veal meat that is absolutely white if the calves are given any food other than milk; this fact is fully realized in France and at least one writer, in all seriousness, has advised the use of chalk, to provide whitening material in a ration, to counteract the bad effects that may be produced in the flesh by feeding concentrates and hay. It is very difficult to imagine that the chalk can have a very whitening effect on the flesh. To produce first-class veal it is essential to feed large quantities of milk, sometimes as much as 2½ to 3 gal. daily. The aim must be to fatten as rapidly as possible, and as soon as a calf can take a particular ration, without scouring, the quantity must be further increased. To facilitate consumption it is essential to feed at least three times daily throughout the fattening period and to give a little rock salt at all times. To expedite fattening the calves for veal should be kept in small, preferably dark, pens to restrict exercise, and with only one calf in a pen; with this scheme it is possible to obtain 1 lb. live-weight gain for each gallon of milk fed. Calves for veal production should weigh 80 to 100 lb. at birth, be healthy calves preferably fat at birth, e.g. Friesian calves, and should gain 150 lb. for 150 gal. of milk fed over a period of not more than three months. As a means of trying to reduce costs some farmers have fed skimmed milk, either fresh or reconstituted from dried skimmed milk, but since some carbohydrates must be added to the ration to make it equivalent to the whole milk the colour of the veal invariably suffers and in consequence the price received falls. If whole milk is not available it is possible to rear for veal on concentrates and hay as for dairy heifers, and provided milk by-products are included in the concentrated mixture good live-weight gains can be made. The feeding should be a little more generous with concentrates than for dairy heifers. This will not produce the best quality of veal meat, but if prices of milk are high this system may prove a better financial proposition than the whole milk scheme described above.

Baby Beef.

Baby beef cattle can be sold at any time of the year and it is possible so to arrange fattening that the fat stock are ready when beef prices are high, namely in November and December and also in May and June. If the stock would normally be fat at other times it is possible to check them and so produce beeflings; it usually pays best to sell stock just at times when prices are highest but in practice this will depend on many factors, e.g. food supplies, prices, housing accommodation, etc.

If baby beef cattle are to be fattened successfully they should be home-bred or home-reared. Failing this, only stock from a well-known source should be fattened for baby beef, otherwise disappointments will ensue. With baby beef production the main difficulty lies in the fact that some classes of stock, especially of certain breeds, will not fatten at a young age no matter how well they are fed; good feeding merely leads to skeletal growth. On the other hand some breeds are too small for baby beef production. Most baby beef is produced from animals from the dual purpose breeds, e.g. Shorthorns (to a lesser degree Lincoln Red Shorthorns), Red Polls and Devons (North), but some will consider the latter to be a pure beef breed. Of the pure beef breeds the Hereford will give the best baby beef stock, the Aberdeen Angus frequently being criticized for giving too little weight for age. If crosses are made with beef cattle bulls on dairy cattle then the Hereford, Sussex and Devon will produce suitable progeny for baby beef production.

For the last 150 years there has been a decided change regarding the ages at which animals have been killed for human consumption, because the consuming public now demand small joints and, as far as can be ascertained, baby beef was not produced in quantity before 1914. Shortly after the World War (1914–18) the production of baby beef gained considerable ground in this country because of the young tender meat that was produced, but farmers found all too frequently that butchers were not prepared to pay a remunerative price for baby beef; in consequence less is produced now than was the case a few years ago. The consuming public do not seem to like baby beef as much as was expected, possibly for the following reasons: (1) it contains a relatively high percentage of bone, (2) it has less flavour than meat from older animals, (3) it contains more water than meat from more mature animals and in consequence shrinks in cooking; thus from the housewife's point of view it is not economical meat. It is also a little unpopular with farmers because the stock have no store period, they must be given only good quality food,

hay and succulents, and they must be given fairly heavy rations of concentrated foods. Baby beef animals do not replace bullocks for they will eat only first-class food and none of the foods suitable for store animals. In general baby beef stock are housed for the whole of their lives; this usually means a fair amount of housing accommodation is required where baby beef is produced. In addition since baby beef production continues throughout the whole year it necessarily follows that stock must be housed, in summer, in large airy yards to give the best results; at such times it is difficult to keep stock feeding and it is often necessary to grow either silage, which may be fed at any time of the year, or to grow green-soiling crops. Whatever system of feeding is involved the production of baby beef cattle demands much expenditure on labour; this is reduced where it is possible to house the stock in large groups or in covered yards.

The early rearing, i.e. to three months of age is as that described for dairy cows in chapter IX, either with bucket feeding and a fairly limited supply of new milk, or with the use of a foster-mother, where several calves may suckle a cow at any one time. Whichever case is adopted concentrates should be given fairly freely, preferably in the dry form, to ensure good growth; hay must be given and also water *ad. lib.* Between the ages of three and six months calves must be given a daily ration that will keep them growing, e.g.

	2 lb.	rising	to 6 lb.		Hay
	5 ,,	,,	,,	14 ,,	Mangolds
or	3 ,,	,,	,,	6 ,,	Silage,
	2 ,,	,,	,,	4 ,,	Concentrates

(meal consisting of equal parts of cracked beans, linseed cake, crushed oats and flaked maize).

It is at six months of age, and when weighing 3 to 4 cwt. that the biggest change is made with the feeding of baby beef calves in comparison to that for dairy and beef store cattle; whereas the store cattle are fed fairly sparsely and may run out to grass the baby beef cattle must remain indoors, since rapid growth is promoted by restriction of exercise. It is possible to reduce costs somewhat by omitting some of the more expensive concentrates and by feeding the relatively cheaper ones. A suitable ration for the six to nine month period is:

6 to 8 lb. Medium quality meadow hay or seeds hay
15 to 30 lb. Mangolds or swedes
or $1\frac{1}{2}$ to 3 lb. Dried sugar-beet pulp (fed moistened)

or 5 to 10 lb. Silage
or 10 to 20 lb. Green-soiling crop, e.g. kale, maize, oats and tares, seeds ley.
4 to 5 lb. Concentrates consisting of
(*a*) 2 parts by weight Crushed oats,
(*b*) 1 part by weight Flaked maize,
(*c*) 1 part by weight Decorticated ground-nut cake,
(*d*) 1 part by weight Crushed rye, barley or dried sugar-beet pulp.

Many rations can be fed and the above is much more flexible than it might appear to be at first sight. It is most important, especially during hot weather in summer, to feed succulent foods if good live-weight gains are wanted. Provided there is sufficient accommodation the keeping of baby beef cattle in groups of about 8 or 10 in yards will usually lead to the most efficient live-weight gains, especially when fattening during the summer.

Passing now to the next period, i.e. nine to twelve months, further increases should be made in the same general rations mentioned above; the animal should reach 6 to 7 cwt. by the time it is twelve months of age. Continuing with the same system of rationing the quantities that should be fed at this weight and age are:

7 to 10 lb. Medium quality meadow or seeds hay,
30 to 40 lb. Mangolds or swedes
or 3 to 4 lb. Dried sugar-beet pulp (fed moistened)
or 10 to 15 lb. Silage
or 20 to 40 lb. Green-soiling crops (as above)
5 to 7 lb. Concentrates consisting of
(*a*) 2 parts by weight Flaked maize,
(*b*) 2 parts by weight Crushed barley, or crushed rye or crushed wheat, or dried sugar-beet pulp,
(*c*) 2 parts by weight Crushed oats,
(*d*) 1 part by weight Decorticated ground-nut cake.

It is just possible that some animals may be ready for sale at this stage; if this is not the case it is rarely necessary to increase the quantity of hay and roots fed daily, but merely to increase the quantity of concentrates to 8 lb. daily and in a few cases up to 10 lb. As increases are made to the ration, shown in detail above, for nine to twelve months stock it is unnecessary to add proteins as they usually form the expensive part of the food—it is sufficient merely to add extra carbohydrate, e.g. dried sugar-beet pulp, or crushed cereals, provided always that the quantity of wheat fed does not exceed 25% of the total concentrates fed. It is possible to add one only of

these foods or to add several, depending on price and the supply available.

It must not be considered that these are the only carbohydrates that can be fed to fattening cattle for that is not true, but it may be stated that these are quite safe and they are usually very palatable. Crushed barley may be used but experience shows that it is not very palatable for the younger stock; it is quite satisfactory when fed, even in large quantities, to the older fattening cattle. Crushed wheat is always a difficult food to use especially when freshly threshed and a little damp and at no time, even with dry corn, should there be more than a quarter of the total ration of concentrates fed as wheat. It is possible to substitute these carbohydrate foods for those shown in the ration, especially when the calves reach the age of nine months but it is very doubtful whether that is worth while for the younger calves.

In some seasons when the prices of concentrates are high, or in some districts where large yields of roots of high feeding value are obtained, it is quite common to feed larger quantities of roots than those indicated above; then it is usual to replace 1 lb. of cereals by about 10 lb. of roots and young cattle not exceeding twelve months of age can eat 60 and 70 lb. of sliced roots daily. The feeding of these larger quantities of roots makes rations more laxative and the protein part of the ration must be modified to include undecorticated cotton cake; then 2 or 3 lb. may be fed daily. Thus the ration shown on page 212 may become:

7 to 10 lb. Medium quality meadow or seeds hay
60 to 70 lb. Mangolds or swedes
2 lb. Crushed cereal or flaked maize
2 lb. Undecorticated cotton cake
1 lb. Cracked beans.

Although it may increase the quantity of protein above the actual requirements of the stock some linseed cake, up to 2 lb. per head per day, should be fed for about one month before killing since it produces a wonderful appearance on the coat and leads to better prices when the stock are sold by public auction.

No mention has been made of dried young grass but there is very little first-hand knowledge available to guide one in this respect. If the dried grass is as rich in proteins as the enthusiasts suggest, then it can replace the protein cake for the whole of the time after the calf is three months of age. It must not replace decorticated ground-nut cake on a pound to pound basis; rather on a 2 (grass):

1 (cake) basis, but with most other concentrates pound for pound will be quite satisfactory. If poorer quality dried grass is available it may be used instead of the carbohydrate foods, but it is often rather more bulky and it would be unwise to feed more than half of the concentrated ration as dried grass for stock under twelve months of age. With the poorest quality dried grass that is produced it should be used merely to replace hay and not concentrates at all.

Bulls.

These animals irrespective of breed are usually reared on rations similar to those given to baby beef stock (and it is for that reason that bull feeding is described in this chapter). There is one main difference, namely, that they may suckle till they are twelve to fifteen months old and thus they will receive milk in addition to the so-called baby beef rations given here. As there are no feeding standards for bull rearing an attempt is made to give in the tables feeding which is based very largely on practice, but it differs considerably from the standard laid down for cattle being kept as stores, or for fattening for beef production (these being the only standards available).

TABLE VIII

RATIONS FOR REARING BULL CALVES (NO SUCKLING)
(lb. per Head per Day)

	Live weight (cwt.)							
	5	6	7	8	9	10	11	12
Best meadow hay	8	8	10	10	12	12	14	14
Mangolds	20	20	30	30	30	30	40	40
Crushed oats	1	2	2	2	2	3	3	4
Flaked maize	1	2	2	3	3	3	4	4
Linseed cake	1	1	1	1	1	0	0	0
Bran	2	2	2	2	3	3	3	3
Dried skimmed milk	½	½	½	½	0	0	0	0

TABLE IX

RATIONS FOR REARING BULL CALVES (SUCKLING OR BUCKET FED) (lb. per Head per Day)

	Live weight (cwt.)							
	5	6	7	8	9	10	11	12
Clover hay	5	6	7	8	9	10	11	12
Silage	10	10	15	15	20	20	25	25
Crushed oats	1	2	2	2	2	3	3	4
Flaked maize	1	2	2	3	3	3	4	4
Linseed cake	1	1	1	1	1	0	0	0
Bran	2	2	2	2	3	3	3	3

After bulls have reached the age for service (about fifteen months) they are not fed according to any standard but according to the condition of the bulls themselves. In order to keep them in a good breeding condition they must be neither too fat nor too thin. In practice they may be fed in the same way as the cows and heifers they are to serve. In summer they may eat grass with no additional foods except perhaps green-soiling crops if the cows have them. In winter bulls will have the same maintenance rations as those given to the cows together with 0 to 6 lb. of the cow's balanced concentrates, the amount being varied from time to time depending on the condition of the bull. Bulls in service, when mature, will not be fed such liberal rations as those shown in the tables for rearing bulls—the latter are being forced, and that is why they are fed so heavily.

The Production of Beeflings.

Again it is possible to time fattening to coincide with periods of high prices, just as was explained for baby beef; in fact it will be remembered that some beeflings may be stock originally intended for baby beef but which would not be fat at convenient times to make a good price and are consequently fattened for a longer period. They may also be stock intended for baby beef which grow instead of laying on fat; such stock may of course have been forced first as baby beef stock.

It is not possible to produce beeflings economically without giving them a store period; in this respect the feeding of beeflings is very similar to the feeding of beef cattle that are being fattened in yards. In both cases many variations of procedure are to be found and to save duplication the actual methods of fattening of beeflings will be described under the heading of fattening mature cattle in yards. Beeflings differ from mature cattle in that, as a general rule, they cannot be fattened on grassland, but of course they may be got into a good forward store condition ready for indoor fattening.

Calves intended for beefling production may be from dual purpose herds, from dairy herds where beef or dual purpose bulls have been used, or from pure beef herds. The early rearing will be by any one of the systems described in chapter IX, and the rearing may have taken place on a farm other than that on which the calves were born. It is quite likely that calves, especially from the dairy farms, will be sold when only a few days old at local markets and bought by farmers who specialize in rearing. As a general rule such calves, by visiting markets, are checked by scouring

because they miss feeds, catch colds, have indigestion and therefore rarely thrive as well as home-bred, or home-reared, calves. It is also quite common to find that calves are sold when they are six months old from the rearing farms; this involves sales via dealers, or markets, or both, and for several days the stock may be poorly fed thus receiving a real check; nevertheless, the system continues in many parts of this country. Depending on the time of year these six-month-old calves are purchased either for turning out on pasture or for feeding in straw yards in winter. Frequently these same stock, when about a year old, in spring or autumn, go through the same performance again except that it will be in the reverse order, namely going from yards to grass or from grass to yards depending on the time of year in question. This will usually continue till the stock are bought by the farmer who is to fatten them. The feeding during the store period will be just about the same as for dairy heifers and the subsequent handling will be as for older stock, which will be described below.

The Production of Mature Beef on Winter Rations.

Various systems may be adopted to produce mature beef during the autumn, winter and spring, the most common method being to buy in stores during the autumn and then to fatten them for four to six months and so have them ready for sale in spring; since many farmers do this, prices are often low in the months of February, March and April because then markets are flooded with stock. Another possibility is to keep the stock out on pasture till Christmas, and then to house and fatten them so that they are sold in May and June when, normally, there is a shortage of fat stock. The last scheme is to start fattening on pasture, by turning the stock on very good pasture in the latter part of the grazing season, and making them fairly fat, either on grass alone or by feeding a little concentrates on the pasture; in this case the stock will be housed, depending on the grass supply, in August or September and sold fat in November and December. Since each case calls for slightly different management each must be described separately.

It must be stressed that beeflings may be given the same rations as those fed to stock fattened for mature beef production, and any of the above-mentioned systems apply equally well to beeflings and to mature beef stock.

Fattening of housed bullocks has undergone various changes during the last thirty years. The old system, often called the Norfolk system, which some farmers still follow, consisted of giving vast

quantities of pulped roots daily; in the final stages of fattening it was quite common practice to feed up to 2 cwt. of mangolds, swedes or turnips daily; although this is rarely carried out to-day to such extremes it is quite common to find 1 cwt. of roots fed daily as mangolds, swedes, turnips and, in some cases, sugar-beet tops. Coupled with the old system was that of feeding chaffed-oat straw; the policy of using chaffed-oat straw has already been condemned elsewhere. Another feature of the old Norfolk system, and rumour has it that it still persists in that county on some farms, was to feed daily 8 lb. of mixture of concentrates consisting of equal parts of cotton cake and of linseed cake. Present knowledge shows this to be very wasteful for more protein is being supplied to the stock than is required for fattening purposes. This excess of protein is used for fattening but it is not used very efficiently because the waste nitrogen is passed out of the body by the kidneys; the extra strain thrown on the kidneys by the elimination of large quantities of waste products is not beneficial. Such feeding of protein cakes is, at their usual high price, exceedingly expensive and has nothing to recommend it, although some farmers are too conservative to try fattening without high protein cakes. These farmers still consider excess of protein fed will lead to better farmyard manure; they forget, however, that usually farmyard manure is so much leached before it reaches the land that the extra nitrogen is usually washed away. The older methods will not be described in detail and attention only will be given to the newer and better methods of fattening.

When fattening takes place during the winter the stock are quite commonly housed immediately after being bought as stores in September or October. At that time mangolds and swedes may not be available and sugar-beet tops, dried sugar-beet pulp, potatoes, kale, kohl rabi or silage may be used. All of these foods are satisfactory for use but care must be exercised in feeding several of them, e.g. chalk should be fed with sugar-beet tops unless they have been wilted for at least two to three weeks and even then chalk is worth while; potatoes are likely to produce "blown" stock if many animals are housed in a yard, and if one greedy animal has more than its fair share. In practice 20 lb. of potatoes may be fed per head to a group of cattle with safety provided no stock eat more than 30 lb. daily. It is occasionally reported that dried sugar-beet pulp may cause "blowing" but that only occurs when it is fed dry; when moistened before feeding (as it should be) no difficulties will ensue. As the season advances mangolds may be used for feeding and generally no difficulties arise, but on a few farms on chalk soils,

and in some seasons, bullocks may have trouble with urinary calculi which may tend to block urinary tracts and so cause difficulty in urination. It seems that only in some seasons and in some areas does the trouble arise and even then it is more common with sheep than with cattle.

When the stock are first brought in for fattening they will weigh 7 to 9 cwt. and they will usually gain 2 lb. per head per day throughout the fattening period. It will be convenient to give a fattening ration at the beginning, half-way through, and at the end of, the fattening period. The authors feel that roots should be used in moderation, but if any farmer wishes to use more roots than the quantity shown it is possible to do so by substituting 10 lb. of roots for 1 lb. of any cereal or 1 lb. of dried sugar-beet pulp.

TABLE X

DAILY RATIONS IN POUNDS FOR VARIOUS STAGES OF FATTENING A BEAST

	Rations in lbs. at		
	Beginning of Fattening Period	Half-way through Fattening Period	End of Fattening Period
Live Weight (cwt.)	8	9	10
Time Fattened (days)	0	60	120
Hay (clover)	8	10	10
Swedes or mangolds	40	40	40
Oat straw	←	*ad. lib.*	→
Concentrates—			
Crushed oats	2	3	4
Crushed barley	2	4	6
Bean meal	2	1	..
Bran	1	–	–
Linseed cake	–	–	1 or 2

All rations are likely to be high in protein during the final stages of fattening, and the above ration in Table X is no exception to the common experience; farmers like to feed linseed cake at the end of the fattening period to produce bloom, that is why it is included here.

It is possible to use a totally different ration by including the maximum quantity of dried sugar-beet pulp and little or no roots. It is also desirable to demonstrate the way in which rations can be calculated for fattening cattle, and since the use of dried sugar-beet pulp provides a simple case it is proposed to use that as an example. If an animal is 8 cwt. at the commencement of fattening and is a good store it will require the following nutrients as can be seen from page 67.

Theoretical requirements	D.M. (lb.)	S.E. (lb.)	P.E. (lb.)
(*a*) for 8 cwt. Live weight	20·5	5·50	1·50
(*b*) for 2 lb. Live-weight gain daily . .	—	4·50	—
Total requirements . .	20·5	10·00	1·50

For fattening cattle it is not wise to calculate a maintenance ration separate from the production ration, for it will be observed that for fattening no protein is required above that of the maintenance ration and it is impossible to add S.E. without adding P.E. to a ration; thus it is far more satisfactory to calculate maintenance and production rations jointly.

	D.M. (lb.)	S.E. (lb.)	P.E. (lb.)
10 lb. Seeds hay	8·60	2·50	0·49
2 lb. Oat straw	1·72	0·45	0·02
8 lb. Dried sugar-beet pulp	7·20	4·85	0·42
2 lb. Crushed oats	1·73	1·20	0·15
1 lb. Decorticated ground-nut cake . .	0·90	0·73	0·41
Total	20 15	9·73	1·49

It is true that this does not give precisely the figures shown in the theoretical requirement but it may be taken as being sufficiently near for all practical purposes.

In view of the frequent relatively low prices of dried sugar-beet pulp it is a sound food to use largely in the rations of fattening cattle; this is even more so where a farmer grows sugar-beet in which case he can buy some dried sugar-beet pulp at a premium. Table XI. demonstrates the advantage of utilizing dried sugar-beet pulp to replace either concentrates or roots in bullock feeding.

TABLE XI
COMPARATIVE VALUES OF VARIOUS FEEDING STUFFS

Feeding-stuff	S.E. in 1 lb.	Equivalent Value of Feeding-stuff per ton for Various Prices of Pulp per ton														
		£	s.	d.	£	s.	d.	£	s.	d.	£	s.	d.	£	s.	d.
Dried sugar-beet pulp . .	0·61	4	0	0	5	0	0	6	0	0	7	0	0	8	0	0
Oats	0·60	3	18	8	4	18	5	5	18	0	6	17	8	7	17	5
Barley	0·71	4	13	1	5	16	5	6	19	8	8	2	11	9	6	2
Maize (cracked) . .	0·78	5	2	3	6	7	11	7	13	5	8	19	0	10	4	7
Maize (flaked)	0·84	5	10	2	6	17	8	8	5	2	9	12	10	11	0	3
Mangolds	0·07		9	2		11	6		13	10		16	1		18	5

In the winter of 1937–8 oats sold for over £10 per ton and growers of sugar-beet could buy dried sugar-beet pulp at £4 10s. 0d. per ton so that the latter was obviously the cheaper food to use; in fact dried sugar-beet pulp was the cheapest concentrated food included in Table XI. Many growers of mangolds maintain that they cannot grow and prepare them for feeding at less than £1 per ton and if that is the case then the pulp is cheaper than the mangolds for feeding. If the mangolds can be grown for 10s. per ton then they may be cheaper than the pulp to feed unless the pulp can be purchased very cheaply by a grower of sugar-beet.

TABLE XII

RATIONS TO PRODUCE 2 LB. LIVE WEIGHT GAIN DAILY

(lb. per head per day)

First Stages of Fattening

	Live Weight in cwt.:—						
	5	6	7	8	9	10	11
Seeds hay	7	7	10	10	12	12	14
Mangolds	28	28	28	28	28	40	40
Dried sugar-beet pulp	3	3	3	4	4	4	4
Crushed oats	2	2	2	2	2	2	2
Decorticated ground-nut cake	1	1	1½	1½	1¼	1	¾

Final Stages of Fattening

	Live Weight in cwt.:—						
	6	7	8	9	10	11	12
Seeds hay	7	10	10	12	12	14	14
Mangolds	28	28	28	28	40	40	40
*Dried sugar-beet pulp	5	5	6	6	6	6	7
Crushed oats	2	2	2	2	2	2	2
Decorticated ground-nut cake	¾	¾	¾	½	½	¼	¼
Flaked maize ..	1¼	1¼	1½	1¼	1¼	1¼	1¼

* May be replaced on the following basis:
1 lb. Dried Sugar-beet pulp = 1 lb. Crushed oats.
1 lb. ,, ,, ,, = 0·77 lb. Flaked maize.
1 lb. ,, ,, ,, = 0·91 lb. Crushed barley.
1 lb. ,, ,, ,, = 0·90 lb. Crushed wheat.
1 lb. ,, ,, ,, = 0·90 lb. Crushed rye.

Provided the total quantity of wheat fed does not exceed 25% of the total concentrates fed.

Large quantities of sugar-beet pulp such as 16 lb. daily may be fed to mature fattening cattle with safety (provided the food is soaked prior to feeding) towards the end of their fattening periods. Rations that utilize fair proportions of dried sugar-beet pulp are shown in Table XII, it being necessary to have two sections because a bullock requires more starch equivalent for each 1 lb. live-weight gain the fatter he becomes; thus in the final stages of fattening a relatively richer ration is necessary to produce the same live-weight gain as that obtained on a poorer ration at the beginning of the fattening period.

Since many farmers still feed large quantities of roots to fattening bullocks it is proposed to give Table XIII again but with roots replacing the dried sugar-beet pulp and the necessary adjustments that ensue. These rations follow closely the theoretical requirements for fattening animals.

TABLE XIII

DAILY RATIONS TO PRODUCE 2 LB. LIVE WEIGHT GAIN DAILY

(lb. per head per day)

Initial Stages of Fattening

	Live Weight in cwt.						
	5	6	7	8	9	10	11
Seeds hay	7	7	10	10	12	12	14
Mangolds or swedes	50	60	60	70	70	80	80
Crushed oats	1	1	1	1	1	1	1
Crushed barley	1	1	1	1	1	1	1
Decorticated ground-nut cake	1½	1½	1½	1½	1¼	1¼	1
Oat straw	←			*ad. lib.*			→

Note.—Decorticated ground nut-cake may be replaced by Undecorticated cotton cake as:

1 lb. Decorticated ground nut-cake }
1 lb. Crushed oats } = 3¼ lb. Undecorticated cotton cake

Final Stages of Fattening

	Live Weight in cwt.						
	6	7	8	9	10	11	12
Seeds hay	7	10	10	12	12	14	14
Mangolds or swedes	80	90	100	110	120	140	160
Crushed oats	1	1	1	1	1	1	1
Crushed barley	1	1	1	1	1	1	1
Crushed wheat	1	–	–	–	–	–	–
Decorticated ground-nut cake	¾	¾	¾	½	½	¼	¼
Oat straw	←			nil			→

Many farmers like to feed high protein rations during the last two or three weeks of the fattening period because they consider it puts bloom on the animals and consequently makes them sell better; for this purpose linseed cake is commonly used and sometimes each bullock is given several pounds daily. This is wasteful, it is expensive, and bullocks can only utilize a certain amount of protein and the remainder is largely wasted. Tables XII and XIII show that only 1 lb. of protein cake need be fed at the end of a fattening period and even that quantity may not be really necessary to provide proteins. Beans are also a favourite food amongst feeders of bullocks because stock do well on this food, but in general beans provide more protein than is required and should be used very sparingly. Special mention should be made of crushed oats for they play a large part in the rations of bullocks that are fattened in Scotland. It is well known that Scottish beef is sold at such a premium that it has, at times, paid Norfolk farmers to send their fat cattle to Scotland to sell them there to obtain a better price (even after paying carriage) than that obtained locally. In England many farmers are tempted to feed oats to fattening cattle, to copy the Scotch rations, but it is very doubtful whether that is worth while at any time when oats are relatively expensive and other fattening foods are cheaper.

The case of bringing in store cattle to fatten at the end of the summer when the aim is to sell them fat at the end of November or for the Christmas Fat Stock markets must be considered. It is obvious that the stock must be in good condition when they are taken in from pasture because the time for fattening is relatively short, and stock usually require over three months in which to fatten. The actual feeding during the earlier part of the summer will be described under the heading of fattening at pasture during summer (this follows the last method of fattening during the winter). The actual date when stock are brought in must depend on the supply of grass, and that in turn, in many districts, depends on rainfall and will vary considerably from season to season. Such fattening cattle should have been grazing on good pasture and gaining in condition; at the first sign that their rate of progress is stopping they should be housed. Sometimes they will remain grazing till September but at other times they will be brought in in early August. The feeding, while still at grass, will depend on the quality of the pasture that is being grazed; if it is good no concentrates will be given, but if not of first-class quality then concentrates must be fed. The time at which concentrates should be fed calls for skilful judgment; if too soon then the cost is unnecessarily

high, if too late then the stock will be in poor condition and they will not be fit for sale at the required time. In many cases feeding of concentrates will start in early August and will continue, even if there is a sudden growth of grass, till the cattle are housed. No scientifically balanced rations can be given for feeding at such times, because the quality of the grass is exceedingly variable. Many farmers give undecorticated cotton cake at the rate of 4 lb. per head daily whenever the grass is luscious, to try to prevent the stock from scouring; experience shows that an abundant supply of late summer luscious grass causes scouring. When the stock do not thrive this cake is given to try to correct this trouble. If the grass is quite normal then a mixture of cereals may be given to the stock while still at grass, e.g. equal parts of crushed oats, crushed barley and flaked maize would produce quite satisfactory results when fed at the rate of 4 to 8 lb. daily to each beast. When stock are being fed at pasture the best results are achieved only if sufficient boxes or bowls are available for each animal to have its concentrated ration to itself; when several animals are feeding from a manger, or crib, especially if at grass, the weaklings may be forced away and starved. Usually before frosts occur these fattening cattle should be housed and then fed in just the same way as described for ordinary winter feeding, except that being half fat they will receive the generous amounts of starchy foods that are given to stock nearly ready for the butcher. Stock being prepared for the Christmas trade (live classes) should be fatter than for ordinary markets, and will usually require more careful feeding than for the normal market because just ordinarily finished stock during the Christmas period sell badly; this is because custom demands well finished bullocks at that time of the year. At Christmas there is always a demand for suet, and suet is produced late in the fattening period, hence stock must be well finished to produce large quantities of suet.

Fattening for the biggest fat-stock shows is a very specialized business for, in the first place, stock must make exceedingly high live-weight gains for their ages; this usually demands abnormal feeding which is done regardless of cost. To entice animals to eat more than would otherwise be the case they are given food at more frequent intervals and, in some extreme cases, may be fed with concentrates as often as five or even six times a day. Another unusual feature of this feeding is to give mashes to entice stock to eat more than they really want; these mashes are given more especially late in the evening, as a "night cap." Also, to maintain appetite and to produce firm flesh, fattening cattle are led for exercise on a hard road

daily; this is the last thing a commercial farmer would do with his fattening cattle because he would be afraid the stock would "walk off" their fat. This forced feeding, described above, is only given to stock intended for the live classes and without a doubt produces meat fatter than is required by the ordinary consuming public. If, on the other hand, stock are required for the carcase classes at shows they need not be forced in anything like the same way. All that is necessary in this case is to get them just ordinarily fat, and to attain this object they are merely fed on dried foods, and as described above for ordinary winter fattening.

After the stock have been sold fat, before, or for Christmas, it is possible to fatten a second lot of cattle in the same yards or boxes; the animals used for the purpose will have spent the earlier part of the winter-feeding period either still at grass, if they are fairly old animals, or they may have been housed but fed on store rations. If stock run out at grass till the end of the year they must be kept in fairly sheltered pastures, but not on the heaviest of clay soils (because they would poach the pastures); while outside, these animals will possibly receive green-soiling crops such as kale or sugar-beet tops and if there is plenty of grass nothing else may be given. If the supply of grass is sparse, or if the weather is frosty, or snow is on the ground, hay may be given in racks, in cribs, or from a wagon which may be taken to a pasture and left till the roughage has been consumed. When the wagon is empty it is hauled to the stackyard, filled and placed in a different place on the field; the latter precaution is necessary to prevent the possibility of poaching and too heavy manuring of the land around the places where the wagon stands. It may be necessary, also, to feed some concentrates to these stock at pasture; the reader may well consider that with so much food being given to the stock they might well be housed to reduce labour costs, for such a field may be merely providing an exercising ground and no more. This criticism may be quite just, and if the food is provided by hand and if there is room for the stock to be housed then it would be cheaper to house them, but frequently they have to remain out of doors until housing is vacated or they may remain out in order to consume old grass. This old grass may be left from the previous summer grazing period and if it is not removed it may actually interfere with growth in the next spring; the removal of such grass is particularly important wherever fattening pastures are involved. At the end of the grazing season it is foolish to force fattening cattle to eat old coarse grass which is more suitable for hungry store bullocks. When these stock are taken into buildings

at the end of December they will be fed as for ordinary winter feeding and they may be forced for selling as soon as possible, or they may be fattened more slowly with the object of selling them fat in May and in June.

Some farmers have been using dried young grass as the sole concentrated food for fattening cattle, but this seems to be very wasteful because of the large amount of protein fed; against this argument it may be said that during the summer stock are fattened on grass and with very satisfactory results. Expense is the main factor to be considered and if dried grass is cheaper than ordinary concentrates then it may be fed, but if not, then it is not worth feeding merely for fattening purposes. It is well known that cattle fattened on grass during the summer produce very little suet (and it is not wanted at that time of the year) and it is only to be expected that stock fattened on dried grass will also produce little suet; if the grass is fed during the winter time then there is the disadvantage that little suet is produced at a time when it is in demand.

The Production of Mature Beef on Summer Rations.

When cattle are to be fattened on grassland the first essential for success is to start with animals of the right age, namely two to two and a half years; if younger stock are used they generally scour too much on pasture and consequently make slower live-weight gains. The second essential is to have the right class of animal for this system of farming; usually stock that are of certain beef breeds or beef crosses make the best live-weight gains, those of Hereford, Devon, Sussex, Beef Shorthorn, Lincoln Red Shorthorn, Welsh and even South Devon blood seem to be best, whereas stock of the dairy type are useless. Breed is not everything and the experience of those who have fattened with success on grassland is that the management of the stock during the winter immediately preceding fattening on grass very definitely affects the financial results. Some feeders hold this opinion so strongly that they go so far as to buy some of their cattle in the autumn to ensure proper handling during the winter. There are also several other advantages to be derived from this policy; storé cattle are relatively cheaper in the autumn than in the spring when feeders are buying for fattening on pasture. When a farmer winters store cattle he can ascertain the thrifty and the unthrifty ones and cull the unthrifty ones profitably in spring. It is also possible to make the stores, trim up pastures during the winter, and so have the latter in first-class condition for the spring growth of grass. Some feeders have land that is too heavy for winter grazing with

cattle and they cannot feed stores at that time; they are forced to buy stores in the spring. Experience shows that not only are stores ready for fattening on grass, expensive in spring, but that they may do badly when turned out for fattening if they have been housed during the winter because they may take some time to become accustomed to grazing. This settling down is very much influenced by the way the stores have been fed during the winter; if they have been out at grass (and this is usually shown by the amount of coat that has developed) and fed very little concentrates they will fatten almost immediately they are put on good grassland. If, on the other hand, the stores have been housed during the winter, and fed relatively large quantities of concentrates, they will carry thin coats; such stores usually suffer from the change of feeding and housing which causes scouring and leads to poor live-weight gains for at least one month after the grazing season commences. When animals have a poor start the result is bad from the financial point of view because it is the stock that are sold off fat in June and July that make the highest prices. Those that are sold fat in September and October usually sell for very low prices because of the large supplies available; these animals leave no profit. Experience shows it to be a mistake to put store cattle that are half fat and that have been housed during the winter, out to "finish" on pasture, because they lose so much condition when first turned out to pasture. Some readers may think that concentrates or hay should be given to such stock to prevent scouring but in general, the stock will not eat such foods when good grass is available. It is obvious, therefore, that when store cattle are being purchased great care must be exercised in selecting them, and for preference they should come from a known farmer who outwinters his stock and gives them very little in addition to grass; half fat stores should be avoided, especially if they have thin coats, which are a sign of housing during the winter.

It is usually assumed that fattening of cattle on pasture takes place only in the Midlands but this is far from true because certain fields in other districts, often known as marshes, are commonly used, e.g. Somerset, Suffolk, Sussex, Lincolnshire, Yorkshire and in many districts on newly laid down pastures. In all of these cases cattle will fatten on certain fields without any concentrated foods being given whatsoever, but for the best results management of grazing must be carefully carried out. Such fattening pastures cannot be discovered by any botanical analysis of the herbage, but rather from experience gained by feeding cattle. A good fattening pasture must have a high-water table, it must not suffer from drought, and it should be supplied

with a permanent supply of drinking-water. The size of the field should be small, experience showing that under ten acres in size gives the best results, larger fields are commonly seen in the Midlands but they often lead to uneven grazing. When fattening pastures are being stocked up in early spring one fattening beast is allocated to one acre of grassland (on poorer land one beast to one and one-third acres); all stock placed into one field must be "mates" (i.e. that have been together previously and in consequence will not fight); the stock that are placed in one field must all be of the same size so that there will be no very definite underlings (animals that are bullied and linger are a nuisance for they prevent the restocking of a pasture with a fresh consignment of animals); all the cattle in one field should be of the same sex (this leads to contentment and to better fattening). As a general rule sheep are also put on a pasture in addition to the cattle at the rate of one sheep to the acre. As the season advances the grazing must be carefully controlled to maintain a continuous growth of short nutritious grass. Under Midland grazing conditions the aim is to assign cattle to a particular pasture and to leave them there till they are fat; this is because moving to a fresh pasture, or adding or removing cattle, checks fattening and should be avoided. Thus the number of stock allotted to a particular pasture must be adjusted very carefully and is, of course, based on previous experience. To allow for the variation in growth of grass at various times throughout the grazing season sheep are used; they may be turned out of a field when the amount of grass is limited, and if the opposite is the case then the number of sheep grazing is increased. It is, of course, quite obvious that a certain amount of grassland that is not of first-class quality must exist on a fattening farm to feed what may, or may not, be surplus stock. This second-rate pasture may be required some years whilst at others it will not be wanted. Sometimes such fields have to be hayed to prevent wastage of stock food. During a grazing season this second-rate pasture may be mismanaged merely to ensure a good supply of pasture; it is possible to graze it down thoroughly during the winter, if it has not been treated properly during the grazing season, as a means of correcting the effects of mismanagement.

Usually fat stock will be sold commencing in late June because cattle will make 2 lb. live-weight gain per day, selling off the grass continuing till late November. In many districts the stock sold early will be fed on grass alone, but where the grass is of poorer quality concentrates may be fed throughout the season; on the better farms, however, concentrates are not usually fed to the first cattle that are

sold fat (unless a small quantity of undecorticated cotton cake, say 2 to 4 lb. daily has been given to prevent scouring during the first spring flush of grass). On the best farms cattle sold after the end of August will often have received concentrates to finish them off when the grass is not at its best. Even the feeding of concentrates will not fatten some stock and these cattle must be housed for finishing or sold as stores at considerable financial loss. It therefore becomes apparent that most so-called grassland fattening farmers often have at least some small acreage of arable land for fattening the few cattle that will not finish on the grassland, or for keeping cattle through the winter as stores. Straw is necessary for bedding and roots are usually required so that a small acreage farmed on a rotation of two crops of cereals (usually wheat and oats) and either roots or seeds is adopted. This arable land serves several useful purposes because it not only provides food and litter, but it also provides a use for labour at various times of the year when otherwise there would be little work to be done.

The arable land, on a grassland fattening farm, must be mentioned from another point of view, namely that of providing concentrates for feeding to stock on pasture. It is well known that young grass is a very rich food which, in particular, contains a high percentage of protein; if grazing is well managed the theorists state that a continuous growth of young grass that is rich in proteins can be obtained throughout the season. It is accepted, therefore (especially when pasture is not first-class) that the concentrates for feeding to cattle fattening on pasture are essentially, carbohydrates; crushed home-grown cereals, cracked maize, flaked maize, rice meal and dried sugar-beet pulp are commonly fed and, to prevent wastage by blowing in the wind, some proprietary cakes are sold which primarily consist of these foods. There seems to be no reason whatsoever for feeding only protein cakes to cattle fattening either on fairly good pasture throughout the season, or on the good pasture at the end of the season, i.e. on the pasture that has been closely grazed in the grazing season. The actual ration of concentrates fed should consist of carbohydrate foods during the first three months of the grazing season, but then it will be necessary to mix one part of a high protein cake to three parts of carbohydrates. On the poorer pastures where cake is fed throughout the whole of the fattening season the protein cake should be used in conjunction with the carbohydrates just as described above. So far no mention has been made of quantities of concentrates to be given daily; here no hard and fast rule can be given for it all depends on the season (which controls the growth of

grass) and the way in which the cattle thrive, sometimes as little as 2 lb. of concentrates may be fed daily, but at others and especially in the autumn, on the pastures that are not quite first class as much as 10 lb. of concentrates may be fed daily during the finishing of some cattle. Where dried grass is available it may be fed with special advantage at the end of the grazing season to cattle that are slow to finish and to provide a gradual transition from grazing to the feeding of concentrates under housed conditions; for feeding throughout the grazing season dried grass is really too rich in proteins.

It is somewhat unusual, but it may be necessary on pastures that are not quite ideal for fattening cattle, to resort to green-soiling during times of drought in the months of August and September. Then maize, cabbages or kale may be scattered on pastures and fed at the rate of 20 or 30 lb. per head daily. On the first-class fattening pastures this is not done because these pastures are not supposed to suffer from drought and also because many fattening stock will have been sold before August.

For successful fattening of cattle on pasture great skill is required in buying and selling well, i.e. a farmer must be a good dealer. The stock must be carefully handled during the grazing season and the pastures must be well managed at all times to maintain a high state of productivity.

XII

FEEDING SHEEP

THE sheep of this country fall into three main groups, namely, mountain, grassland and arable land; these names describe the areas where the sheep are bred and not where they are fattened. In general mountain sheep are small, hardy and very active, and are naturally rather slow maturing; owing to the increasing demand for small joints, however, the numbers that fall into this category are exceedingly numerous. Half of the total number of ewes found in this country are of the mountain type. Under natural conditions feeding is simple and for convenience it will be described last. The grassland breeds of sheep are rapidly disappearing in this country, except for the production of rams, because they are large, coarse and produce joints that are too large for modern requirements. These grassland sheep are being replaced principally by sheep of the mountain type, and if the present rate of change continues for a century most of the grassland breeds will be extinct. Arable land sheep have become less popular during the last twenty years because of the high cost of labour that is required to hurdle breeding sheep on arable land; on many farms, however, it is still the custom to purchase lambs for fattening during the autumn and winter on roots. The arable sheep are early maturing and, if sold when young, are small; at the present time the main function of the flocks of the real arable breeds is to produce rams for crossing purposes. Since the feeding of sheep on arable land calls for the most skill it will be described first; it may be used as a pattern when describing that of the other classes of sheep.

Some mention should be made of the sizes of flocks that are commonly found under the various systems of sheep-keeping in this country. The modern tendency is to aim at keeping sheep in men or ram units. Under arable conditions one man can look after 300 breeding ewes and their followers provided he has some help at lambing time, or if sheep are being fattened on roots one man can look after up to 600 sheep without any assistance. Under mountain conditions 600 ewes and their followers can be maintained as a man

unit. It is usual to find farmers keeping a one-man unit of breeding ewes on an arable farm of some 500 acres of light land; with mountain sheep a farmer may have several men units of sheep. With grassland it is rare to find a flock of 600 breeding ewes but commonly multiples of ram units of 50 to 60 ewes per ram. This has an unfortunate effect on the sheep on grassland because it usually means that only a part-time shepherd is required, and all too frequently no shepherd at all, anyone, often no one, looking after the sheep. At busy periods of the year, e.g. at hay time quite commonly the grassland sheep are neglected with very undesirable results. The fact that small flocks are usually very poorly shepherded is a very considerable practical disadvantage.

Arable-land Sheep.

The true arable-land breeds of sheep usually spend the whole of their lives on the plough land; there is a tendency, however, for breeding ewes, as soon as the lambs are weaned, to remain a few weeks, possibly two months, on grassland. It is often considered good management to arrange for pregnant ewes to go for a part of each day, or all night, on grassland to enable them to clean their feet, to provide dry food, to give a dry bed and to give them a moderate amount of exercise. Sometimes ewe tegs may spend a short time on grassland, from May till July, when they are flushed ready for service. With these exceptions it is usually true to say that arable-land sheep live entirely on arable land. This involves growing special crops for the sheep and, since sheep must live in winter on the arable land, they can be kept only on the lighter soils; crop failures occur sometimes and it is difficult to ensure a sufficient supply of food throughout the year. It seems essential, at this stage, to give a folding calendar, to show the various foods that are available at different times of the year; for convenience times of planting are also given to show the difficulties that may be experienced in producing crops on light land at certain seasons of the year. It will be noticed that many of the folding crops are drilled in the late spring or summer; at such times, and in some years, light land may suffer from drought. Kale is a particularly valuable food that has not received the attention that it deserves, because it is the most nutritious "root" crop that can be grown for sheep on many soils and it is available for a long time. "Seeds" are useful because they may be fed over a long period, provided the right kind of grasses and clovers are used. Sometimes a field of seeds may be folded as many as three times in one season,

but young sheep must never follow old ones at an interval of less than one year (because of parasites); in some districts fertility is built up by repeated sheeping instead of by using the dung cart. In view of the short period of the year that it is available for feeding, trefoil is surprisingly popular for it gives no aftermath but it provides food at an awkward season of the year. Mangolds are an exceedingly useful safeguard because they may be fed to sheep for over half the year, should that be necessary owing to poor yields from other crops. At the present time a few farmers look upon dried sugar-beet pulp as an insurance similar to mangolds.

Since arable-land sheep are folded for so much of the year it seems necessary to describe the essential features of good folding. Whenever sheep are being folded there is a battle between the farmer and the shepherd. The former is usually interested in making each crop last as long as possible, and to clear up the whole crop with the sheep; on the other hand a shepherd, who is interested in his sheep, is anxious for them to thrive well and he wants them to receive just the best of the crop and he resents making his sheep clear up a crop properly. Folded sheep must have a new fold each day and they must also have a large "run back", i.e. four or five days' old folds to give them exercising room, and to prevent them from being crowded into a small fold in wet weather; this crowding puddles the surface. In the "run back" the sheep are usually fed concentrates and hay; around the troughs and racks the manure is dropped abundantly and unless food receptacles are moved on daily, uneven manuring ensues. Good folding consists of placing the troughs and racks on the poorer parts of the field, where the crop is thin, to entice the sheep to manure those parts of the field; it is possible, therefore, with good management to leave a field evenly manured after sheeping, and for it to grow a more uniform crop than it grew before sheeping, also the opposite may occur with bad folding. Whenever the sheep are moved from one field to another changes of diet should be made gradually; a sound practice is to bring a small quantity of the crop from the field to which the sheep are going and to feed it on the field that the sheep are leaving. This has several advantages, in addition to making the change in the feeding very gradual, keeping the sheep longer on the old field results in the last few days' "run back" getting better manured than would otherwise be the case, also there is a space cleared on the new field to provide "run back" as soon as the sheep arrive. Even when the folding is carefully done it is impossible to prevent the last day's fold on the old field being under-manured, and, to a less extent, the folds of the

FOLDING CALENDAR FOR ARABLE-LAND SHEEP

Times of Folding	Crops Folded	Times of Drilling Crops
January*	Sugar-beet tops Swedes Turnips 1,000 head kale Marrow stem kale Rape Mangolds	April and May May and June July to September April to August ,, ,, ,, ,, ,, ,, April and May
February* and March*	As January except no sugar-beet tops	
April	Turnip tops 1,000 head kale Rye Winter barley Winter oats Rape	September June to August September September September August and September
May*	Trefoil Trefolium Oats and tares Seeds and sainfoin	April (previous year) August and September September April (previous year)
June*	Cabbages Seeds and sainfoin Oats and tares	July and August April (previous year) September and October
July*	Cabbages (2nd growth) Seeds and sainfoin aftermaths Mustard Oats and tares	August April (previous year) May October and November
August	Cabbages (2nd growth) Seeds and sainfoin aftermaths Marrow stem kale Mustard Oats and tares White turnips Kohl rabi	August and February April (previous year) February to April May and June March and April April April
September	Cabbages Mustard Seeds and sainfoin Marrow stem kale White turnips Kohl rabi	April and May June and July April (previous year) March and April May April and May
October	Cabbages Mustard Seeds and sainfoin Rape Kale (marrow stem) White turnips Sugar-beet tops	April and May July and August April (previous year) June April and May. July April and May
November and December	As October	

* Indicates that Mangolds may be used to supplement folds.

three previous days, because on most of the field the sheep can have a "run back" for four to five days during which time such land will be receiving manure.

All sheep should have access to salt licks which contain either pure salt or, in districts where the soil is known to be deficient in certain minerals, with those deficient minerals added. Whenever sugar-beet tops are given to sheep some farmers, to prevent scouring in their sheep, feed a small amount of chalk with the concentrated ration or place chalk in a trough in the fold, for experience shows that sheep will eat it if they require it.

Special mention must be made of the question of water. At many times in the year sheep are eating very luscious grass, or succulent crops, and they do not require water. During the summer, however, and especially when pastures are dry, and burnt up, or sheep are folded on very mature seeds ley they will not thrive to their maximum capacity if they do not receive water daily. It may be rather annoying to have to cart water for sheep more or less daily, but the keenest shepherds are confident that it is worth while; they find that lambs receiving water will fatten whereas those receiving none will not. All stock must have water, and because sheep do not require to have it constantly supplied for nine or ten months in the year farmers frequently do not bother to give it for the remaining months.

Turning now to the feeding of the breeding ewes, during a year, it is necessary to point out that at least four different classes of ewes are found on arable land, namely

(1) the pedigree arable-land flocks that lamb on and after January 1st,
(2) the non-pedigree that lamb in December,
(3) the flying flock of ewes that lamb during the winter,
(4) the Dorset horn ewes that lamb down throughout the year but more especially in the months of September, October, November and December.

Here it is proposed to describe the feeding and management more especially of the pedigree arable-land flocks, because it will be very similar to that for ewes in groups (2) and (3), but it will not quite fit the ewes in group (4). It will be convenient to trace the feeding of the breeding flock through a year and to commence with flushing. Ewes are usually fed poorly after weaning and till flushing commences, then suddenly they should be given a plentiful supply of very good food, e.g. aftermath sainfoin or seeds will do well for this

purpose, or even mustard is sometimes grown. This sudden feeding of very good food leads to a sudden release of ova from the ovaries of the ewes, and results in a higher fall of lambs, it also leads to more ewes coming on heat in a short space of time, and so reduces the length of the lambing season. The advantage of the latter lies in the fact that when lambing starts the ewe flock is rapidly divided into three or four flocks; this increases the labour of shepherding and as soon as lambing has finished it is possible to keep just one or possibly two flocks. A short lambing period greatly reduces the labour of shepherding. For service some shepherds divide the ewes into groups of 60 and put one ram to each group and so with a flock of 300 ewes they may have 3 flocks of ewes and 2 flocks of ewe tegs or 4 flocks of ewes and 1 flock of ewe tegs; in these cases young rams will be put to the old ewes, and old rams to the ewe tegs. Other flock masters keep all ewes together, but run 2 rams with the ewes by day and 2 more by night; experience seems to show that bigger falls of lambs are obtained with the divided flocks, but the latter means more work for the shepherd as the ewes are kept in several folds. In the flocks where a very high priced pedigree ram is used he will be kept away from the ewes and a teaser, who cannot serve ewes himself, but merely indicates those on heat, will be run with them; as ewes come on heat they are taken from the flock for service. This service with valuable rams, which is known as "hand riding," requires much labour in removing ewes for service, but the advantage lies in the fact that a valuable ram can serve 200 ewes by this method whereas if he is merely running with the ewes in the ordinary way he can cope with only 60 ewes because in the latter case he serves some repeatedly.

Just before the tupping season is due to begin it is essential to get the rams into a good breeding condition; they actually breed better if they, and also the ewes, are in a rising condition. The way in which the rams are prepared for service is to feed them concentrates for a month or two (if in poor condition) before they are required for service, if they are old rams; ram lambs are usually forced so much that they will require no extra feeding as the breeding season approaches. Some flock-masters feed rams on beans alone at the rate of 2 lb. per day; this is rather wasteful in proteins, and a cheaper ration, and one that is more likely to give satisfactory results, is a mixture of equal parts of crushed oats, cracked beans, flaked maize and linseed cake, fed at the rate of 2 lb. per head per day. During tupping time rams may be so concerned about service that they will not eat concentrates whilst with the ewes; such rams

rapidly lose condition. If a ram will not feed during the breeding season, while still running with the ewes, it may be necessary to remove him daily from the flock for a few hours, but experience shows that even then some rams will not feed at such times. Some shepherds go further and run one ram with the flock by day and another by night; this affords each ram plenty of time for feeding during each twenty-four hours. This latter system is of course useless in a pedigree flock because many ewes may be served with both rams and accurate recording of ancestry is impossible. When the tupping season is over it is usual to feed the rams sparingly till being prepared for the next breeding season. Even with arable-land flocks the rams are often turned on to grassland till they are required again for breeding. The above feeding applies to arable-land rams and to a certain extent to those of the grassland breeds but not to mountain sheep breeding, for they are usually given no artificial foods.

When the ewes are settled in lamb no special feeding is necessary till about half-way through pregnancy, except that it is a mistake to give pregnant ewes excessively large quantities of roots daily. There is a well-known saying that "a good root year is invariably followed by a bad lambing season," which is probably true. Big rations of roots seem to lead to a big mortality in lambs, especially before lambing takes place; in some seasons ewes have putrified lambs. Thus a certain amount of dry food, i.e. hay or rough grazing, is essential for in-lamb ewes and unless it is given trouble will ensue. A maximum of 16 lb. of roots a day is a safe ration and ½ lb. of hay or even good straw such as pea haulm or oat straw, will give satisfactory results during the first half of pregnancy, during which time seeds ley, cabbages, kales, turnips and mustard and sugar-beet tops will be the chief foods given.

Half-way through pregnancy a certain number of the ewes will begin to appear unthrifty and lose condition, these ewes are usually young ewes that are changing their teeth, old ewes that have lost their teeth, and ewes that are carrying twins or triplets. It is good management to isolate these unthrifty ewes from the main flock immediately they show any signs of losing condition and to feed them concentrates in addition to hay and to their fold. They may be fed ¼ to ½ lb. a day of a concentrated mixture such as—

1 part Cracked peas or beans,
1 part Brewers' grains (dried),
1 part Crushed oats,
1 part Decorticated ground-nut cake.

It is not possible to be very scientific about feeding at this stage because standards are not available. The experience of flockmasters seems to be that plenty of proteins is required at such times, and some breeders feed no concentrates other than beans to pregnant ewes. Whenever in-lamb ewes feed from troughs especial care must be exercised to see that ewes are not injured by crowding; abundant trough room is absolutely essential.

As the time for lambing approaches all sheep must be fed more liberally, and concentrates may be increased to 1 lb. per head per day to the ewes that are inclined to be unthrifty, whilst $\frac{1}{4}$ to $\frac{1}{2}$ lb. should be fed per head per day to the ewes that have not received concentrates formerly. For the last month of pregnancy the quality of the hay fed should be raised, straw should be replaced by hay, and the quantity of hay allowed should be increased to 1 lb. per head per day. A good crop to fold ewes upon, as lambing commences, is kale or swedes or combinations of the two drilled alternately 4 rows or 6 rows of each.

With an arable land flock of ewes lambing usually takes place in a lambing pen; the old method was to use a permanent structure, but such places usually became so rife with disease that at the present time temporary lambing-pens are much more popular. Temporary pens are usually built of hurdles, or bales of straw, and are placed on the arable land, but always with a good supply of roots, for folding, in the vicinity. Ewes that have not lambed are usually kept as near the lambing-pen as food supplies will allow, and as they show signs that lambing is about to commence they are put into the lambing-pen; there they will usually remain completely for the first 3 to 7 days after lambing, depending on weather conditions. As lambs get strong, and provided the weather is suitable, ewes and the lambs are put out on the fold for a few hours daily. For a week this treatment may continue, after which the ewe and her lambs will remain for a whole day on the fold, generally returning to the lambing-pen at night; a further week may elapse before the ewe leaves the lambing-pen for good. It is obvious that with so much movement to and from the lambing-pen the latter must be so placed that there is a good supply of roots on all sides. As each ewe remains in the lambing-pen for several weeks a good supply of hay and roots are also necessary in the lambing-pen itself.

From time to time orphan lambs are bound to arise through the deaths of ewes; in a few cases ewes may have either no milk at all or they may have insufficient milk for all their lambs. Thus it is frequently necessary to provide milk for these lambs by one of

several means. It is possible to feed these lambs artificially on a bottle, but there are many disadvantages to this scheme, the main ones are:

(*a*) That on some farms no cows are kept and it is difficult to arrange for a milk supply unless a few freshly calved cows are purchased specially for lambing time (this is sometimes done when arable land ewes are kept).

(*b*) It is a nuisance to warm milk before each feed if it has got cold.

(*c*) It takes time twice or thrice daily and a shepherd may find it inconvenient for the bottle-feeding to be done at a constant time daily; if a rigid time-table is not adhered to digestive disorders will occur.

(*d*) It is impossible to produce first-class milk for lambs from cows' milk because the latter is more dilute than that produced by the ewes.

Thus bottle-feeding is not popular as a commercial proposition, but it is frequently resorted to by the shepherd's wife, or by the farmer's wife, or where there are families in which there are children to look after the lambs more or less as pets. There is very considerable risk of making these bottle-fed lambs pot-bellied, because they are invariably fed large quantities of milk at irregular intervals. It is difficult to give actual rations of milk, but it seems that ewes with twins will often be producing half a gallon of milk a day. Some shepherds stop bottle-feeding when the lamb's belly at each feed is level with its flanks; this is quite a safe indicator if the lambs are fed at frequent intervals daily. The practical aim is to put these lambs on foster-mothers. Ewes that have lost their own lambs will usually have milk and they may be persuaded to adopt the foster lambs; ewes that have only one lamb of their own may, with some breeds, be made to adopt a second lamb. Some ewes will take quite readily to foster-lambs, whilst others may refuse to take any interest in them at all. When the ewes have lambed several days, and the foster-lambs are several days old, it may be necessary to pen the ewe with the lambs; if she is spiteful to the foster-lamb, or lambs, she may be kept tied up by a halter continuously; if she is not spiteful, but refuses to allow the lambs to suckle, she may be tied up only at suckling times. Ewes vary considerably, for some will adopt lambs readily, whilst others may take several weeks before they will let the lambs suckle freely; the latter class of ewe must remain penned in until she takes to the lambs properly.

If by any chance there are some orphan lambs and a ewe loses her own lamb or lambs various devices are, at times, resorted to, to

entice a ewe to adopt some orphan lambs. Often the only way a ewe may be persuaded to adopt a lamb, after her own single has died, is to cover the orphan with the skin of the dead lamb. This is contravening all the rules of hygiene, and if the first lamb has died of any infectious disease there is the possibility the second one may do so likewise. If a ewe has twin lambs and one dies, it is possible to replace the dead lamb by an orphan, and to smear both with some strong-smelling substance, e.g. creosote, so that the ewe cannot recognize her own lamb by smelling it.

If a ewe is discovered whilst lambing to have one or two dead lambs then it is possible to smear some foster-lambs with her "waters," and if all is carefully accomplished then the dead lambs may be smuggled away and the ewe will accept the foster-lambs with the minimum of trouble. Shepherds are normally adept at persuading ewes to take foster-lambs because if that is not well done more lambs have to be reared on the bottle. This same general procedure may be adopted, if a ewe has a single lamb, and if she has sufficient milk for two an orphan may be smuggled to her during, or immediately after, lambing.

When a ewe dies during, or immediately after, lambing, the orphan lambs should be put with all possible speed on to a freshly-lambed mother because the lambs should have colostrum. When orphan lambs are very weak a mixture of a cup of warm water and a teaspoonful of glucose, with a little whisky added, will, if given to them, usually produce better results than will a ration of cows' milk. Shepherds usually like this prescription, and are very keen that whisky should be present in their medicine-chests!

When orphan lambs are successfully fostered by ewes, suckling will of course continue for the normal period of three or four months, depending on circumstances. If bottle-rearing is being done that is discontinued as soon as possible, which is when the lamb is eating hay and concentrated foods well; this is usually when the lamb is at least one month old.

Succulent food is ideal for ewes immediately after lambing, and roots are usually the most convenient succulent to use in the lambing-pen. They may be thrown down whole on the straw and the ewes will usually chew them up. Hay is usually provided in racks, or cradles, and concentrates are frequently given in troughs. Taking the arable districts as a whole, it seems that the following foods are the most popular for breeding and suckling ewes: Oats, barley, maize, peas and beans, linseed cake, ground-nut cake and undecorticated cotton cake, bran, dried brewers' grains, dried sugar-

beet pulp and locust beans; many flockmasters have their own ideas on feeding which are not always sound, from the scientific point of view. For simplicity some breeders feed equal parts of cereals and protein cakes to breeding ewes, and this gives approximately the correct nutritive ratio.

Scientists have provided fairly satisfactory standards for the feeding of suckling ewes; maintenance requirements are published according to live weights and for milk production a ratio of 4 lb. starch to 1 lb. of protein is required per gallon of milk. This ratio is the same as for dairy cows, though formerly a 3 : 1 ratio was recommended. A review of various rations that have been used by farmers leads to the conclusion that sheep are given too little proteins. Various carefully-run experiments show that a ewe will produce 2½ to 3½ gallons of milk per week. It seems that the scientists cannot agree amongst themselves as to the amounts of starch equivalent and dry matter that ewes require, and will consume; one school of thought puts the dry matter capacity some 20% lower than the other and the starch equivalent nearly 30% lower. For safety it is proposed to take the higher figures in each case and to show the method by which a normal weekly ration for a suckling ewe can be calculated.

TABLE XV

OLD STANDARD RATIONS FOR A EWE

(lb. per week)

	D.M.	S.E.	P.E.
	lb.	lb.	lb.
Theoretical requirements per week:			
Maintenance 160 lb. L.W.	*33·00	12·00	0·62
Production 3 gall.	—	12·00	3·00
Total requirements per week	*33·00	24·00	3·62

	D.M.	S.E.	P.E.
	lb.	lb.	lb.
126 lb. Thousand head kale	19·91	12·98	1·76
5 ,, Clover hay	4·17	1·59	0·35
1½ ,, Cracked peas	1·29	1·03	0·27
2 ,, Linseed cake	1·78	1·48	0·49
2 ,, Crushed barley	1·70	1·42	0·15
2½ ,, Crushed oats	2·17	1·49	0·19
4 ,, Flaked maize	3·56	3·36	0·37
1 ,, Locust bean meal	0·85	0·71	0·04
Total	35·43	24·06	3·62

* This may reach 40 lb. with ewes.

This is quite a satisfactory ration from all points of view, and many practical men use the same ingredients as are included in it. It will be noticed that the ewes eat more roots after lambing than they eat before, in fact the whole food intake is increased.

On page 83 it will be seen that another standard of feeding is given for ewes which suggests less S.E. than that given on page 240. This illustrates the controversy that is raging between experts at the present time. In Table XVI a ration is worked out for comparison with that showing the more orthodox theoretical requirements. This revised ration is very concentrated and it will be seen that it is difficult to keep the D.M. down to the theoretical figure.

TABLE XVI
NEW STANDARD RATIONS FOR A EWE
(lb. per week)

	D.M.	S.E.	P.E.
Theoretical requirements per week:	lb.	lb.	lb.
Maintenance 160 lb. L.W.	27·60	7·70	0·62
Production 3 gall.	—	12·00	3·00
Total requirements	27·60	19·70	3·62
140 lb. Swedes	16·10	10·22	0·98
3½ ,, Clover hay	2·92	1·11	0·24
2 ,, Linseed cake	1·78	1·48	0·49
4 ,, Cracked beans	3·43	2·63	0·79
2 ,, Flaked maize	1·78	1·68	0·18
2 ,, Decorticated ground-nut cake	1·80	1·46	0·82
1 ,, Crushed barley	0·85	0·71	0·07
1 ,, Crushed oats	0·87	0·60	0·08
Total	29·53	19·89	3·65

When ewes that have twins are milking freely, or if ram lambs are being forced for early sales, or shows, it is frequently necessary to keep these lambs and their dams away from the main flock and to feed them extra concentrates; such ewes may have as much as 7 to 14 lb. of concentrates per head per week a short time after lambing. Usually as soon as lambs start eating concentrates they are given a special mixture separate from that given to the ewes, and to ensure that only the lambs receive it they are run "forward in the creeps." This term "forward in the creeps" can be explained in this way; special hurdles, fitted with adjustable vertical rollers that may be moved laterally to let through lambs but not ewes, are used on the fold to allow the lambs to go forward one day before the ewes. By this means the lambs have the pick of the crop

that is being folded and they may be fed concentrated foods separate from the ewes. As soon as the lambs start eating concentrates (that is when they are ten days old) it is usual to reduce the daily ration given to the ewes by the same amount as that being consumed by the lambs while "forward in the creeps." A suitable mixture of concentrates for lambs consists of equal parts of the following: linseed cake, crushed oats, flaked maize and bean meal. If by any chance the lambs should start scouring it is not possible to correct this trouble directly by altering the diet of the lambs because young lambs will be eating very little, if anything, besides their mothers' milk. It is possible to correct scouring in lambs by altering the feeding of the ewes by reducing the size of fold daily; this reduces the succulent ration then the quantity of hay fed is increased and by including, or increasing, the proportion of undecorticated cotton cake in the ewes' concentrated mixture the trouble may be eradicated. Sudden changes of feeding of this kind will usually correct scouring in lambs in the course of a few days. Some feeders make no changes in the ingredients of mixtures for lambs during the whole of the suckling period, they merely increase the daily ration till a maximum of about 1 lb. per day per head is consumed when the lamb is three or four months old, by which time, of course, the ewes will be receiving little or no concentrates. Other feeders change the mixture gradually from a fairly high-protein ration to a low-protein ration as growing and fattening advances; by the time of weaning or of selling fat a ration of 2 parts of flaked maize, 2 parts of crushed oats and 1 part linseed cake, is being fed.

If at any time ram lambs are being prepared for sale they demand special treatment consisting, primarily, of a high-protein ration such as is given as the first concentrates after lambing, and in addition, three or four feeds a day with mangolds added. They must also receive a fair proportion of hay to ensure that they do not scour with the liberal feeding of concentrates they receive. During the cold weather it may be necessary to put up lambing-sheets around the folds to form wind breaks for the lambs (this may be worth while for all lambs, but especially for rams wanted for breeding). During the hot spells of weather in summer it may be advisable to erect awnings, some six feet high, over the ram lambs; if this has been done, it is often too inconvenient to move such erections on the field and it is often necessary to cut and carry green food to the lambs while they are under the awning. During the summer, bran is a good concentrate to include in the ration of ram lambs and experience shows that the following ration is very satisfactory for such sheep.

3 parts Crushed oats.
3 ,, Bran.
1 part Flaked maize.
1 ,, Cracked peas } or 2 parts of either.
1 ,, Cracked beans }
1 ,, Linseed cake.
1 ,, Locust bean meal added if lambs inclined to scour.

Often these ram lambs may be sold when they are still suckling, but for the normal lambs of the flock weaning will take place either when sold fat to the butcher, i.e. straight from the ewes, or when the lambs are four months old. When a lamb is sold "off the ewe" it is customary to try and find the ewe concerned, and if she is suckling no other lambs to remove her from the fold and to put her on a grass field, or on to a poor fold to arrest milk production, and to reduce feeding costs; such ewes will not, of course, receive any concentrates. If a lamb is sold from a ewe and she is rearing twins she must remain with the suckling ewes till her second lamb is either sold or weaned. When the time for weaning the whole flock arrives, the lambs are usually shut away from the ewes by keeping the former in the fold in which they receive their concentrates for increasingly longer periods daily, till the ewes are removed altogether. At that time the ewes should be taken out of earshot of the lambs and fed on poor food to arrest milk production; all ewes that are being retained for breeding will be fed as cheaply as possible, either on poor grassland, or as scavengers behind the lambs on arable land, till flushing commences. The ewes must not be put as scavengers behind the lambs till their milk has disappeared, otherwise neither the ewes nor the lambs will settle in their respective folds and some may jump out into the wrong fold. The ewes are fed sparingly until they are flushed for the next breeding season.

At weaning time the ewe lambs will be fed rather sparingly and in general will receive no concentrates; they will, in fact, be fed on a store ration for just over twelve months, i.e. until they are themselves flushed for breeding when 18 or 19 months of age. Wethers may run with the ewe lambs and for a time receive similar feeding, but on the other hand they may be pushed for mutton production; the actual policy adopted will usually depend on the current prices of mutton and lamb. If the wethers are not fattened immediately they will usually receive store rations until they are fattened in the following autumn and winter. Ram lambs for breeding will be treated especially as has been described earlier.

Ewes are often culled from the flock at weaning time for one or

more of the following points—old-age, udder troubles, bad mothers or poor teeth (the non-breeders will have been sold fat at the end of lambing). The next question to consider is disposal; sometimes it will be a sound procedure to sell these ewes at weaning-time in a store condition (for someone else to fatten or to breed from) or it may be better to sell these old ewes fat. The latter scheme often leads to a high charge where a relatively small number of sheep are kept, because usually they will be folded and they may require chopped or sliced roots or kale and chaffed hay; the expense of preparing these foods is high, especially when the number of sheep is small (the normal culling being only 20 to 25% of the number of the number of ewes in the flock). A suitable weekly ration for these old ewes (often called crones) that are usually fattened during the autumn and winter is:

140 lb. Swedes.
7 lb. Seeds hay.
1 lb. Decorticated ground nut cake.

1 lb. Crushed oats 1 lb. Flaked maize 1 lb. Dried sugar-beet pulp	Increasing each to 2 lb. about half-way through fattening period.

(Many feeders would prefer to replace this pulp by crushed oats on a pound for pound basis.)

The ewes that are sold in a store condition may be purchased to enter what are known as "flying flocks," which are usually composed of culled ewes from several different flocks and may consist of sheep of any breed. A "flying flock" is bought and served as soon as possible with or without flushing, the latter being the more common. The ewes are fed fairly generously during pregnancy so that they lamb down in good condition; thereafter the ewes and lambs will be fattened together on the same rations as those suggested for pedigree ewes and their lambs, the only difference being that with the flying flock the ewes are fed well all the time after lambing, whereas with the pedigree flock the quantity of concentrates fed daily falls as the lambs eat more themselves. A very simple concentrated mixture that is used for such ewes may be equal parts of beans, oats and linseed cake, while a liberal root ration is given both before and after lambing; in the latter case the quantity of concentrates fed daily may reach as much as 2 lb. per ewe. With the flying flock the aim is to sell both the ewe and the lamb together when they are fat, and it may be necessary to pulp roots, and chaff hay, for the ewes if this object is to be achieved.

The last important class of sheep to be considered on the arable land are those that are being fattened there during the autumn and winter; various classes of sheep may fall into this category, namely, lambs born on arable land, grassland or on the mountain-side, also a few older sheep, even ewes, may be included. To obtain good prices in most districts the sheep must be sold fat; after the last fat sheep have been sold from the grassland at the end of October, and before the new season's lamb is available in large quantities and at reasonable prices; this means that the fat sheep must be sold after October and before the end of March. During this period there are usually large quantities of roots available, as can be seen from the folding calendar, in some seasons, when roots are plentiful, store sheep are so much in demand that prices are ridiculously high. Some farmers make it their general policy to buy, annually, store lambs for fattening on roots in winter; they find it more convenient to fatten in this way because they can avoid the difficult feeding period of April and May, and because they can buy sheep according to their estimated yields of roots. This practice has a further advantage to the community in general for mountain-sheep farmers can breed sheep, but they cannot fatten them on the mountain and the lambs from these ewes are usually fattened on arable land, sometimes in the valleys near the mountains on which the lambs have been born, but more commonly in other districts. For financial success the store lambs must be bought at a reasonable price and sold as early as possible in the fattening season, for there is always the chance that prices may be a little low at the end of the winter, due to too many sheep being sold at that time.

Store lamb sales or fairs are usually held in many districts during August and September, but they are sometimes held both earlier and later, depending on the locality and the class of sheep being sold; lambs are not usually sold till old enough to be weaned or till they have recovered from the check in growth produced by weaning. Given normal store lambs they should fatten in about three months, during which period they will have gained at the rate of 1½ to 3½ lb. per head per week and most frequently at 2 lb. per head per week, and gained in all 30 lb. live weight. It is unwise to sell an unfinished sheep because it will not usually command a high price; on the other hand the finished sheep must not be too heavy for the market in which it is being sold. In many districts a wether for mutton should not exceed 100 lb. live weight, in others 120 lb.; also certain markets demand certain breeds. It is therefore most important to purchase store lambs of the right size and breed that will enable one to produce

fat sheep which will command a good price locally. When stores arrive on the farm their feet should be inspected thoroughly for foot rot, and if necessary they should be treated, because lame sheep will not thrive. It may also be a sound procedure to drench the sheep for worms, because sheep will not fatten properly if their intestines are infested with parasites. When relatively large rations of roots are fed a concentrated ration that is sometimes fed to fattening wethers is 3 parts barley or oats (crushed), 3 parts of undecorticated cotton cake and 1 part of linseed cake. A suitable feeding plan suggested, giving weekly rations in lb., is in Table XVII.

TABLE XVII

FEEDING PLAN FOR FATTENING SHEEP—OLD STANDARD

(Weekly ration in lb.)

	1st Period	2nd Period	3rd Period
	lb.	lb.	lb.
Live weight in lb.	80	90	100
Swedes	100	110	110
Hay	3½	3½	5¼
Crushed oats	1	1½	2
Flaked maize	1	1	2
Decorticated ground-nut Cake	1½	1½	—
Linseed Cake	—	—	½

In Table XVII the fattening period is divided into three periods, each being of approximately one month's duration.

The above rations are low in dry matter according to some authorities, though others would consider that they supply abundant amounts of all nutrients required. To demonstrate the way in which rations are calculated for sheep, Table XVIII will serve as an example:

TABLE XVIII

	D.M.	S.E.	P.E.
Theoretical requirements per week	lb.	lb.	lb.
Maintenance 100 lb. L.W.	24·00	9·00	0·38
Production 1¾ lb. L.W. gain	—	3·50	1·37
Total requirements	24·00	12·50	1·75
100 lb. Marrow stem kale	13·9	9·00	1·30
5¼ „ Seeds hay	4·51	1·31	0·26
1 „ Dried brewers' grains	0·90	0·48	0·13
1 „ Dried sugar-beet pulp	0·90	0·61	0·05
½ „ Cracked peas	0·43	0·35	0·09
½ „ Flaked maize	0·43	0·42	0·04
Total	21·07	12·17	1·87

It will be noticed that the ration is high in protein, although less cakes are being fed than are used in many rations; also that the D.M. is low, but many will question the validity of the published figures (theoretical) especially in view of the work recently published in which the following ration appeared and gave good results.

	D.M.	S.E.	P.E.
	lb.	lb.	lb.
10½ lb. Meadow hay	8·82	4·26	0·82
1¾ „ Linseed cake	1·56	1·29	0·43
7 „ Flaked maize	6·23	5·88	0·64
Total	16·61	11·43	1·89

Sheep fattened on such a ration made more than expected live-weight gains; this has indicated the theoretical requirements were high.

There is also some difference of opinion, as with the ewes, regarding the level of starch equivalent that should be fed. If the lower level is taken it will be seen that the result in Table XIX gives a ration containing relatively high-protein concentrated foods. The newer level makes it difficult to produce a ration which is sufficiently high in dry matter and yet supplies enough proteins.

TABLE XIX

RATIONS FOR FATTENING SHEEP—NEW STANDARD

(Weekly ration in lb.)

	D.M.	S.E.	P.E.
Theoretical requirements per week: ..	lb.	lb.	lb.
Maintenance 100 lb. L.W.	19·70	5·60	0·38
Production 1¾ lb. L.W. gain	—	4·37	1·40
Total requirements ..	19·70	9·97	1·78
100 lb. Swedes	11·50	7·30	0·70
3½ „ Clover hay	2·92	1·11	0·24
1 „ Bran	0·87	0·60	0·12
1 „ Linseed cake	0·89	0·74	0·25
1 „ Decorticated ground-nut cake ..	0·90	0·73	0·41
Total	17·08	10·48	1·72

It is not possible to discuss all the ways in which lambs are reared in this country, but in view of the fact that more and more attention is being paid to the production of out-of-season lamb some mention

should, perhaps, be made of a special way in which the breed of ewes, Dorset Horns, that produce out-of-season lamb, are handled. There is a special luxury demand for "house"-fed lambs throughout the year, and to meet that demand the Dorset Horn ewes must be used. Sometimes one flock is kept, at others culled ewes are kept to produce the lambs more or less at usual seasons; the Dorset Horns being served to lamb especially out of season. To produce best-quality lamb, which gives a dead weight of 16 lb., the lambs are housed and fed almost exclusively on milk. The ewes lie in at night, during which time the lambs suckle, and move out on grassland or arable land, depending on the food available for the day-time. This artificial way of keeping sheep will not appeal to many and that is perhaps fortunate, for any appreciable increase in the number of farmers producing in this class of meat would lead to bad prices. The Dorset Horn breed is also kept to produce fat lamb for the Christmas trade; in such cases the flock is handled as a normal arable land flock, and folded on roots and both ewes and lambs given the same kinds of concentrates as described for ordinary arable land flocks.

Grassland Sheep

Many sheep are bred on grassland, and a few that have been bred elsewhere are fattened there. Taking the breeding sheep first it is quite convenient to start again at the time of flushing, it being noticed that flushing is carried out just as in the case of arable land breeds. Flushing is done by running the sheep on arable land, or on grassland, in the former case crops may be grown especially for the sheep, e.g., kale, or rape, or superfluous crops, e.g. seeds, or crop residues may be consumed, e.g., cabbages and sugar-beet tops. When flushing is done on grassland it is usual to turn the sheep on pastures that have not been sheep-grazed for several months, the longer the period the better; such fields may have been grazed all summer by other stock, e.g., cattle only, or they may have been hayed and the aftermath may have been cattle-grazed only. When sheep are first put on grassland that has been rested from sheep for a period they thrive particularly well and so the flushing effect is produced. If, on the other hand, owing to drought, the pasture that had been reserved for flushing has been used for ordinary grazing it is possible to flush ewes on grassland by other systems, either by green-soiling or by feeding concentrates to the ewes. Either of these schemes will produce the desired effect, but practical men always consider that

fresh grass produces slightly the bigger fall of lambs, so that flushing with concentrates is only practised when the grass supply is limited. A common way of feeding concentrates to ewes is to sprinkle whole beans daily on pasture at the rate of ½ lb. per ewe, no troughs being necessary as the ewes will find and eat all the beans. The actual time of flushing varies from district to district, in some cases flushing must take place in August for lambs are wanted in February, but in others lambs are not expected till April and the flushing takes place in October or even in November. If ewes are grouped for flushing they will usually run in those same groups for mating, that is, in groups of about sixty ewes. The time of lambing is arranged by some farmers to coincide with the spring growth of grass, whereas others consider that the lambs should be born sufficiently earlier so that they can eat young grass as soon as it comes in the spring, i.e. when the lambs are three to four weeks old. Some breeders always plan to have lambs fat earlier than their neighbours.

For the actual service the ewes are very commonly grouped into fifties or sixties, each group being put into a separate field. After rams have been running with the ewes for six weeks, quite commonly the groups of ewes are amalgamated to reduce the work of the shepherd which is heavy when he has ewes in several fields. It is still considered worth while after amalgamation to have a ram with the ewes for a further period of about three weeks. During this time a few extra ewes may be served, but it is a mistake to leave the ram for a longer period because late lambs may result, and they are always a nuisance because of the labour involved. After the flushing and during service no change need be made in the feeding except to move the sheep on to a fresh supply of grass or roots as is necessary.

When the majority of the flock have been pregnant for two or three months all ewes should be inspected, and those not in first-class condition should be isolated and fed better than the rest. Shepherds in general object to this procedure because the ewes that are picked out must remain in a separate field and that, of course, increases the labour of shepherding. These ewes that are not in first-class condition must be given hay and/or concentrates, if they are not fed especially well they will be weak at lambing time, and a certain percentage may die; they may have weak lambs that are difficult to rear, or the ewes may have little or no milk for the lambs. From the shepherd's point of view the last is the worst feature, because it may mean that bottle-feeding may be essential. This demands labour daily throughout the suckling period and if a shepherd grumbles about isolating part of the flock into another field, it may be well to stress

the point that it is being done to increase the milk supply of those ewes; then a shepherd will usually admit that it is worth while. Such ewes may receive beans, or possibly proprietary sheep-nuts, thrown on the pasture at the rate of ½ lb. per head per day, or, if troughs are used, a mixture may be given as for ewes on the arable land. As the time of lambing approaches it may be necessary to feed concentrates to all breeding sheep because they must lamb down in a fairly fit condition. If at any time there is a fall of snow ewes may be unable to eat sufficient grass to keep alive; good management demands the feeding of hay to these ewes, and, to save wastage, racks should be used on the grassland. Elaborate racks are not necessary and if no racks are available two hurdles placed close together, either standing up vertically and held in position by stakes or sloping towards one another so that they meet at the top, will serve to reduce wastage from wind and from scattering by sheep. If the supply of grass is limited roots such as whole mangolds may be scattered over the grassland twice daily, and left for the sheep to eat at will; care should be exercised to ensure that the quantity does not exceed 14 lb. daily lest difficulties should arise at lambing-time through excessive feeding with roots. Some grassland sheep-breeders grow kale for feeding to their ewes just before, and just after, lambing; in these cases the ewes will usually run on pasture at night, to provide them with a dry bed, and be folded on the kale during the day. Good results will be achieved provided the quantity of kale allowed per head is not excessive.

Lambing usually takes place on a grass field, but it may be on arable land. In some cases no preparations whatsoever are made for lambing, in others lambing-pens may be erected on some secluded corner of a grass field. In the latter case the aim is to pen a ewe and her lambs together for a minimum period of twenty-four hours to make sure that they settle down; also to be certain that a ewe has a good milk supply for her lambs, because it may be necessary to arrange for a foster-mother for a lamb where a ewe has insufficient milk for two lambs. It is also customary to erect hurdles in crosses to afford shelter on grassland where ewes are lambing during cold wind or rain.

After lambing, mangolds may be thrown whole on the pasture, hay may be fed in racks, and concentrates may be fed in troughs or thrown out on pasture, but when there is sufficient growth of grass nothing is usually given in addition to the natural vegetation. Much of the feeding will therefore depend on the growth of the grass and, that in turn, will depend on the time of the year. The feeding after

lambing may also depend on the aim of the farmer which may include any one, or various combinations, of the following:

(1) Feed liberally all lambs and sell them fat as soon as possible.
(2) Feed lambs on grass and on ewes' milk alone and sell as store lambs.
(3) Force only single lambs by feeding concentrates to sell them fat and sell twin lambs as stores.
(4) Force twin lambs but not the singles so that all are ready together to sell as stores, or fat.

Experience shows that farmers vary the procedure they adopt, depending on current prices, or expected prices, and also upon the markets that are available in their vicinity (market prices are often influenced by the yields of roots expected).

As lambing proceeds farmers usually separate ewes and lambs into flocks, depending on the way in which the lambs are to be fed and also according to age. It is often very convenient to divide the breeding flock into groups of some sixty head to facilitate control of grazing. Undoubtedly lambs thrive best if they are not moved constantly from field to field; this usually means that the whole flock cannot be run together, because the sheep will eat the grass so rapidly that they have to be moved to fresh fields every few days, whereas if ewes are in smaller groups this is not necessary. Heavy sheeping of grassland such as is produced by running a large flock together may also result in forcing ewes and lambs to eat near to their own droppings; those especially from ewes may be fairly heavily infested with eggs from internal parasites, which, when ingested by the lambs, may retard live-weight gains.

It is unusual to feed concentrates to ewes after the spring flush of grass has arrived; if the aim is to force the lambs, they are usually given concentrates in creeps, which are composed of hurdles with narrow passages which allow the lambs to enter to eat concentrates from troughs. The actual mixtures fed will be precisely the same as for lambs on arable land, e.g., crushed oats, flaked maize, bran and decorticated ground-nut cake mixed in equal proportions and fed at quantities of up to 1 lb. per head per day, depending on conditions and aims of the farmer; but of course many lambs that are sold as stores receive no concentrates whatsoever. In a few localities it is the custom to feed roots to the ewes till the supply has been consumed and that may easily take till the end of May or even June. Where the system of alternate husbandry is adopted, experience shows that in general first-class grass is produced on which the

lambs fatten quite readily (even on very poor quality soil) without any concentrates; some farmers find these leys are good in the initial stages, but that they will not finish the lambs and that the latter must be fed on roots and concentrates if they are to be sold fat.

In some districts the ewes are allotted to the grassland at the rate of one ewe and her lambs per acre, but in others they may be kept at the rate of two ewes per acre, and on Romney Marsh up to five and six ewes per acre. It is well known that the worst enemy of a sheep is another sheep, and that Romney Marsh sheep are less affected by internal parasites than are any other breeds of sheep; this breed can be used at a heavy stocking rate per acre without any trouble ensuing both on the grassland of the famous Marsh, from which they receive their name, and also in the orchards of Kent where sheep are the only stock ever used for grazing, because cattle would damage the trees.

Weaning is accomplished quite easily by removing the ewes out of ear-shot of the lambs and by having the latter on good pasture for a time. The ewes are normally turned out on pasture of poor quality, or wherever the herbage will benefit from "baring down." These ewes are therefore kept cheaply till they are required for flushing. Meanwhile the lambs will be fed according to the aim of the farmer, i.e., for the store, or for the fat, trade. As soon as the lambs have been weaned is a convenient time to worm both the ewes and lambs. No worming can be successful without fasting and it is foolish to fast a suckling lamb for twenty-four hours because that may "dry" off the ewe, and it is not possible to fast the ewe, for that also may "dry" her off. The main object of worming sheep is to treat them for fourth stomach worm for which copper-sulphate solution is excellent; this may be given as a drench, whilst arsenical compounds may be given as pills at the same time. It is also a wise procedure to treat ewes for worms just before they are served and, on arrival, any new ewes, ewe tegs, or ewe lambs, brought on the farm. With sheep, and especially grassland sheep, internal parasites must never be forgotten; close grazing should be avoided, and lambs should never follow old sheep when grazing, because old sheep are much less susceptible to the effects of internal parasites, and consequently, though they suffer little ill-effects, they may be heavily infested with the parasites and broadcast them wherever they graze. If lambs are not fattened on grassland while still suckling their dams, they are not usually fattened on grassland during the first year of their lives, but instead on the arable land on roots, for which purpose many will be sold at the lamb fairs. Since so many lambs are sold at these fairs it is quite obvious that on some grassland farms the sole object of

keeping breeding-sheep is to produce store lambs for sale there. Fattening these lambs on arable land has already been discussed.

A further class of sheep found on grassland should be mentioned; and they are the yearlings of grassland and mountain breeds that are fattened in such places as on the good pastures of the Midlands. There it will be remembered the fattening cattle are the main consideration and the sheep are used to assist with the grazing, and at the same time they must get fat themselves. Such sheep are frequently purchased in the autumn and consist of many different breeds and crosses, wintered on the second-rate grassland, living on nothing but grass, except in very snowy weather when hay may be given. These sheep trim up the pastures in the autumn and winter during which time some will get fat and in the spring the remainder will fatten. On a diet of grass, and grass alone, these sheep are sold fat by the end of July. The usual rate of stocking is one sheep to every bullock, and since this type of grassland will carry one bullock to the acre, it follows that the sheep stocking is relatively high. In some seasons when grass is scarce concentrates will be given to finish these sheep; but the aim is to fatten them as much as possible on grassland.

The Mountain Sheep.

Mountain sheep are more varied as regards size and food supply than any other class of sheep; some live on precipitous cliffs, others on cold peat bogs whilst some may live on chalk downs; some have a plentiful supply of grass whilst others live on heathers, sedges and grasses that even some of the breeds of mountain sheep would not touch. Some land is so poor that instead of considering the stock-carrying capacity in terms of sheep per acre the opposite is stated namely the number of acres required to keep a sheep (and a very small breeding-sheep at that). With such a wide range of conditions it is very difficult to discuss feeding and management in general terms. Usually lambing takes place much later in the year under mountain conditions than on grassland or on arable land, owing to bad weather and the lateness of growth of food supply in spring; some farmers do not want many lambs till late April, or even early May where ewe lambs are bred from, but many exceptions to this general statement may be found, e.g., in Devon lambing often starts in early February; in Wales, especially in pedigree flocks, as early as late January; in the Kerry Hills and parts of Yorkshire mid-March is selected. These are only a few of the exceptions but there are many more which might have been cited.

Breeders of mountain sheep are quite agreed on one point, and the worse the conditions the more definite are they concerning this point, namely, that of flushing: with mountain sheep twin lambs are not wanted, one good strong lamb per ewe is the aim of the farmer. Under mountain conditions twins are too weak to go up the hillside early in spring, the ewes have insufficient milk for two lambs; if there are twins they and the ewe suffer. With mountain sheep the food in the valleys must be conserved for winter grazing and for hay production; to ensure sufficient growth of the latter the ewes must be high up the mountain in the spring and summer consuming food in the worst exposed conditions. The production of twins delays all movement up the mountain side.

Frequently no attempt can be made to control the breeding for a number of rams are turned into the ewes (one ram to forty ewes) during which time the ewes are not usually on quite the highest land. After service, in many districts, no changes are made in the feeding except that with advancing winter and bad weather trough-feeding with hay and with concentrates may be essential. Some mountain-sheep breeders consider that hand-feeding sheep results in producing big lazy animals that will not fend for themselves, and they will not feed anything to their ewes, in fact they are not concerned if the ewes lose condition throughout the winter; it does seem, however, very dangerous practice to get the ewes down in condition and weak when heavy in lamb and there is always the danger of loss of ewes. It has been stated that some mountain sheep will not eat concentrates and hay but the writers are inclined to doubt this; many breeders who at one time maintained that hay and concentrates should not be given to ewes now provide these foods. With some of the mountain breeds, e.g., in Dartmoor and in North Wales, roots are also given to ewes before and after lambing, thus the so-called hardy breeds will eat roots if given the opportunity. The actual concentrates used will be the same mixtures as those described for the arable land flocks.

Lambing usually takes place in sheltered valleys and on the best-quality grassland on the farm. If no artificial feeding has been given before lambing none is given afterwards, except in very bad weather conditions, but if hay and concentrates and some roots have been given daily before lambing, then that will be continued afterwards; if any change is made then the quantity should be increased. With the majority of mountain ewes, however, no hand-feeding will be given in addition to the grazing. The worst weather for lambs is snow and rain, the latter often leading to losses by drowning on the lower

slopes. As soon as lambing is safely over then, assuming it to be late May, the aim is to push the ewes and their lambs as high up the hills and mountains as possible, to consume grass there and allow the low-lying land to produce hay. No artificial feeding to the lambs is attempted up the hillside, and it is quite obvious that the conditions do not lend themselves to such feeding either.

Experience shows that fattening of lambs on the mountain while suckling ewes under most conditions, is not a practical proposition, but instead the best thing to do is to sell the lambs as stores for fattening on arable land. Formerly the mountain sheep were retained on the mountain and sold when 3 or 4 years old as fat mutton, but that is no longer done. No attempt is made to prepare the lambs for sale by artificial feeding; shepherds improve their lambs merely by controlling the grazing by directing their sheep to various parts of the mountain under their control. Sometimes crosses are made rather than breeding pure from the ewes; no more famous, or popular, cross can be mentioned than the half-bred (Cheviot ewe x Border Leicester ram). The ewe lambs from the cross are sold for breeding purposes when 5 to 6 months old, or at 12 months or at 18 months, and usually not at other times, the actual policy depending on the development of the lambs, the current prices and the possibility of retaining the lambs on the farm during their first winter. Often accommodation is so limited that only the ewe lambs for the home flock can be retained, the wether lambs must be sold. Usually these lambs are sold at the autumn fairs for fattening on arable land.

Any ewe lambs retained for breeding join the new flock again immediately after weaning in August and live under very hard conditions, very high up in the mountains in the autumn, but they will be kept on lowlands in the winter. Ram lambs for breeding usually receive forcing treatment to a degree, but not with the view of preparing them for service at seven months, rather to ensure adequate growth during the spring and summer whilst suckling.

The life of the ewe under hard mountain conditions is short and experience shows that on the average ewes will not spend more than three lambing seasons in the flock; thus replacements are high. The culled ewes are sold in August and September for further breeding in better localities, but no special feeding is necessary to prepare them for sale because these ewes sell at relatively good prices. These ewes usually find their way to arable land for feeding, and the majority of the lambs are also fattened on the arable land, the mountains being, in many cases, the breeding and rearing-grounds for the arable areas.

XIII

FEEDING PIGS

PIGS are quite different from all other animals that are usually found on farms because they have relatively small digestive systems. In consequence, ordinary roughages are never given to pigs, and succulents only in moderate quantities; even good quality grass is too bulky for sows to thrive upon, unless some concentrated foods are given as well. So great is the pig's inability to digest fibrous material that concentrates must be carefully selected, and those containing fairly high percentages of fibre should be used in limited quantities, or not at all. Fibrous foods must be avoided more when pigs are under 100 lb. live weight than subsequently.

On the other hand it seems that pigs can utilize large quantities of liquid food, e.g., skimmed milk or whey, provided the nutrients contained in the liquid are easily digested. In some countries, where large quantities of skimmed milk are available, it is reported that pigs being fed for bacon production will consume as much as 15 to 20 gallons of skimmed milk daily.

In order to assist the relatively weak digestive system of the pig, foods may be ground, soaked and cooked. Grinding concentrates is most important for young pigs, and food must be very finely ground when it contains a fair percentage of fibre. For sows grinding is not essential; to them it is not uncommon to feed whole cereals during pregnancy. When whole grains are being fed they should invariably be soaked for 12 to 24 hours prior to feeding to facilitate chewing and to aid digestion. This is by no means the only occasion on which soaked foods should be given to pigs; some farmers soak all concentrates before giving them because they are convinced that pigs digest them more efficiently. This is quite justifiable provided the foods are soaked for 12 to 24 hours, but if they are moistened just at feeding-time, it is difficult to see just how that will aid digestion. Moistening of dry food after it has been placed in the troughs may, however, give two very important advantages, namely, it will prevent wastage by blowing if feeding is being done in the open, or in exposed places, and it will often reduce the labour of feeding; the

carrying of water which arises with wet feeding is obviated if water is sprinkled over the ration by means of a hose pipe. Opinion is very much divided upon the relative merits of wet and dry feeding as also are the ideas on giving water *ad lib.* to pigs. For sows there can be no doubt that they must have plenty of water available at all times, especially in hot weather and when suckling pigs. When little pigs start eating dry food they seem to require water to drink, and although some breeders are afraid of giving them water *ad lib.* because they consider that it leads to a pot-bellied condition, many breeders find that no such troubles arise and always provide a liberal amount of water.

Some water is, however, essential for fattening pigs, many breeders consider that the giving of a large amount ultimately leads to a carcase that is too fat, and in consequence they give their pigs the minimum in their wet concentrates. On the other hand, many breeders feed their pigs both dry and wet, for they give two soaked feeds daily and leave dry meal and water constantly before the pigs; they find good quality bacon ensues. As a means of demonstrating that the liberal supply of water has no detrimental effect upon bacon, it may be pointed out that in dairying countries, where large amounts of skimmed milk (up to 20 gallons per pig daily in New Zealand) are given to pigs being fattened for bacon (and skimmed milk is 90% water) the quality of bacon produced is excellent judged by the requirements of this market. It is, therefore, difficult to understand how a liberal supply of water can be harmful, to pigs intended for the bacon-curer.

Potatoes are usually cooked for pigs because it increases the food value by at least 33% over that of the raw potatoes; wherever pigs are kept near buildings and there is any convenience for cooking, potatoes should be cooked for fattening or for breeding pigs. The food value of potatoes is fairly high—3·4 lb. of cooked potatoes being equivalent to 1 lb. of barley meal; it is unwise to feed potatoes to pigs before the latter weigh 100 lb., and thereafter the daily ration should not exceed 8 lb. per pig per day, even for mature sows, if the potatoes are to be utilized efficiently.

If hotel, or house, swill is being fed to pigs, the law requires that it shall be cooked before it is fed to prevent it acting as a horrible medium for the spread of disease; for all other foods, with the exception of maize, however, cooking is not worth while, as has been proved by various experiments that have been carried out in the past.

No general discussion on the feeding of pigs would be complete if no mention were made of the feeding of various dairy products

and by-products. If a suckling sow is short of milk at any time after her piglings are about six weeks old, it is often possible to keep the piglings alive by feeding them whole milk, skimmed milk or even moistened dried skimmed milk. Milk products are unquestionably valuable in such a case as this. When large litters are weaned it is often observed that there may be several small piglings; such pigs will derive considerable benefit from any milk products that may be available. The above examples show the benefit of milk products for special cases, but it must be explained that whenever they are available milk by-products are excellent food for ordinary healthy animals. It appears that the proteins and minerals of milk products are exceedingly valuable to pigs on account of the ease with which they may be digested, and the fact that the proteins and minerals present are especially suitable for the growth and development of young animals. It is also well known that pigs thrive better if a small proportion of milk by-products is included in their ration, than if the same nutrients are provided from other sources. So valuable are these dairy by-products that the dried forms are often included in rations for piglings at weaning time, and for about a month afterwards despite their high cost. Some practical men consider the pig industry of the country is penalized because large quantities of milk products are not available at low prices, as is the case in many countries who are sending bacon and pig products to Great Britain.

Pig foods are placed in various receptacles at feeding-times; the wooden trough is cheap and fairly durable provided that the parts that pigs can chew are covered with strips of steel ribbon; concrete troughs are easily cleaned, but unless they are built into a pen there is always the danger of cracking and breaking when they are moved; various iron troughs are used which are quite satisfactory from all viewpoints, except that they are made of cast-iron, and are liable to be broken when moved by pigs or by farm-workers.

All troughs must be cleaned periodically for pigs never thrive if their food is being given to them in sour troughs. They must be cleaned whether pigs are being fed on wet or on dry foods.

Whenever it is the custom to give pigs their meals dry it is always worth while considering the possibility of providing self-feeders for the pigs. Self-feeders must be made with care, especial attention being paid to design to prevent "bridging" in the food. To prevent this a common form of agitation is obtained by slinging the food supply into a trough or hopper so that pigs bunt it in order to obtain a further supply of food, thus the food is shaken down as required.

Experimental evidence shows that the following advantages may arise from the use of self-feeders:

(*a*) Quicker live-weight gains may be made.
(*b*) Less food is required per lb. live-weight gain (provided the feeder is properly adjusted and food is not being wasted).
(*c*) It is applicable to pigs of all ages.
(*d*) It may replace wet feeding or merely supplement it.
(*e*) It reduces labour especially where pigs are on pasture and foods must be carted out at frequent intervals.

The special cases where self-feeding is of particular value are for little pigs that are still suckling, and for forcing fattening pigs, because they will eat more food when it is left continually before them. It must be remembered that some types of self-feeders are badly designed and much food is wasted; if the feeder is in the open air much may be blown away if meals are used; cubes may be used in self-feeders to prevent losses by blowing when feeding is taking place out of doors. Whenever pigs are being fed from self-feeders plenty of water must be available so that piglings can drink at will after they have consumed some dry food, for no self-feeder has, as yet, been designed that will cope with wet foods. There is just the possibility, however, that with an abundant supply of food before them, pigs may over-eat and produce excessively fat bacon when killed and cured.

As a means of reducing costs it is the custom in some districts of the country, and especially where there are plentiful supplies of straw, to house pigs in yards which may be under cover or partly in the open. Yards may be filled with in-pig sows, suckling sows, weaners, stores, or fattening pigs, but all pigs that are in any one yard must be of the same approximate size or age. It is essential, if the best results are to be expected, to ensure that all the pigs can sleep under cover. Pigs thrive quite well in big groups provided they can all receive their fair share of food, and hence plenty of trough-room is essential. An economy that is sometimes made, and with considerable success, is to provide one feeding-pen or "dining-room" for the pigs to go to from several different yards; the advantages are: (*a*) the dining-room can be made with a concrete floor and is easily cleaned, (*b*) the dining-room can be near the food supply and so reduce labour at feeding-time, (*c*) less food is wasted by spilling because all food can be put out in the dining-room for each relay of pigs before they arrive, whereas buckets are often upset if they are to be carried into a yard, or pen, of hungry pigs that are fighting for

their food, (*d*) one supply of utensils will suffice for several yards of pigs because they may be used for several relays of pigs, (*e*) there are less troughs to keep clean, and (*f*) food does not go sour in the troughs. There is, however, one very serious disadvantage of the common dining-room, namely, the risk of spreading disease. If by any chance there was a serious outbreak of disease many more pigs would have been in contact with the troughs, at which the sick pig may have been, and a disease might easily spread rapidly throughout the whole group of pigs. It is therefore exceedingly important to watch very carefully for the first signs of a pig being off feed, in which case it should be removed from its yard and fed and housed separately; if this simple point is observed then risks of disease should be reduced to a minimum.

With this yard system often as many as 50 to 100 fattening pigs, or possibly 30 sows, may be in one group, and provided the pigs remain healthy, and they all get their fair share of food, housing in big groups is sound because it reduces labour costs. When a sow is farrowing she must be in a pen to herself, as is usually the case for the first week or ten days after farrowing, but thereafter she may be put with other sows. For fattening many farmers favour putting 10 or 12 pigs together in a pen, but unless they are carefully matched for size, and even then the difficulty often arises, they are not all ready for sale at the same time and pens may be kept for several weeks half empty. It is unwise to make up fresh pens because strange pigs fight, when put together, especially when a small number from one pen are put with a large number from another pen. If, on the other hand, as pigs are weaned they are run together in big groups, it is possible to select pigs of the same size when 100 or 150 lb. live weight, for the pens for the final fattening; if they are approximately the same size when selected the chances are that all will fatten at about the same rates. Even when 50 pigs are being fattened in a yard, it is often considered wiser to select the 10 fattest and to force them by feeding them separately in a box, then as the numbers dwindle in the yard, either the pigs may be moved to smaller yards, or the pigs of two yards may be amalgamated because no trouble will ensue when many pigs are involved.

The keeping of pigs in big groups, or moving them from their pen to a "dining-room," provides these pigs with sufficient exercise to keep them healthy, but if pigs are kept in very small pens, as is frequently the case, they frequently go "off feed," become stiff and unthrifty. When this stiffness is first observed the pigs should be roused up and made to run around their pens early in the mornings,

at noon and as late as possible at night. It will be observed that whenever the pigs are disturbed they invariably micturate and there seems to be evidence of the connection between too little urination and stiffness; if there is too little micturation uric acid may accumulate in the system and that may be the real cause of the stiffness.

Turning now to the feeding of various classes of pigs, it is proposed to deal, in the first instance, with breeding pigs and later to consider rearing and fattening. Since no special feeding is commonly given at the time of mating it is a convenient stage at which to commence the description of feeding a sow. At the time of service the sows and gilts may be housed in yards where up to 20 sows may be running together; rarely if ever, are healthy in-pig sows housed in individual pens until they are about to farrow. Alternatively the sows (gilts are implied also) may run out on pasture with no shelter, or with a shed provided for sleeping and also for shelter in very hot weather. Sometimes sows may be running in woodlands, provided there is a sound fence around the outside; this may afford shade and shelter without any expenditure of time and money on housing. If sows are kept outside they are healthy, and good healthy litters should ensue, but if sows are in yards there is always the danger of anæmia occurring, and of the piglings doing badly after they are born. On the other hand very unhealthy sows may be found on grassland; this is especially the case where the same land has been used for sows for too long a period. The land becomes heavily infested with parasites and then it is very unsuitable for pigs. The length of time it takes for a pasture to become heavily infested is not known, for it must clearly depend on the parasite infestation of the stock placed on the field, and the intensity of stocking with pigs; many practical men state that the same field should not be used continuously for more than two years, whilst some say one year. In this country there must be many pig runs that have been used continuously for pigs for nearer twenty than two years. Some farmers are even more cautious and put sows on fresh grassland every six months; this is perhaps ideal, but the chief difficulty lies in the cost of fencing. It is expensive to move wire fencing that will keep in sows, for posts must be put securely into the ground; it is possible however to use hurdles, the best being made of corrugated-iron, but they are very expensive and are only used when sows are more or less folded on arable land. The modern electric fencing is cheap and effective and can be strongly advocated for sows.

Whenever sows are grazing on pasture, impediments should be placed in their snouts to prevent them from breaking up the turf.

Many of the pieces of wire and rings that are put in sows' noses are very ineffective, and must be replaced at frequent intervals; it is possible to use a better type of ring, namely a small-sized bull-ring, which must be attached well back into the nose and fixed so that it hangs from the centre of, and across, the nose from nostril to nostril. Some farmers consider that sows only dig into the ground when they are being fed rations that are deficient in some minerals, but this is not necess..rily the case (although it may be sometimes), for a sow's natural tendency is to dig with her snout, its shape being especially suited for that purpose.

There has been much speculation regarding the exact amount of grass a sow will eat when grazing; so far no one has ascertained the answer precisely, because, although it would be possible to feed a housed-sow cut grass, it does not necessarily follow that the same sow would eat that same quantity of grass if she had to pull it at pasture herself. It seems that in winter very little grass will be consumed, so little that it may be omitted from any rations, but in summer so much may be consumed that a sow's concentrated ration may be reduced by as much as four to six pounds daily without adversely affecting her condition. For any season of the year it is difficult to feed a better ration than the famous ration in Table XX.

TABLE XX

A FAMOUS MIXTURE FOR BREEDING PIGS

40% Barley meal.
30% Weatings.
20% Bean meal.
10% Fish meal.

to pregnant sows, but if they are at pasture mealy rations are liable to blow about and so become wasted, so some farmers prefer to feed a balanced cube which will not be blown away. When sows are safely settled in-pig a very simple, though quite satisfactory, ration is to throw soaked whole maize and soaked whole beans on the pasture; the actual rations will depend on the amount of grass available. When grass is plentiful the ration will be two maize to one of beans, but when grass is limited equal quantities of each of these foods will be given. During the summer in-pig sows require as little as 2 to 4 lb. of concentrates daily, depending on the grass supply and the condition of the sows; but if it is winter, or if the sows are housed in summer, they will require about 8 lb. of meal or concentrates per head daily. The actual quantity will depend on the condition of the

sow, for she must not be too fat, on the other hand she must carry sufficient reserve at farrowing time, and for suckling, because she will invariably lose condition during suckling if she provides milk for a litter of average size even if she herself is fed generously.

As a means of reducing costs the rations in Table XXI have been used with success in feeding breeding-sows when the prices of the usual carbohydrates have been too high:

TABLE XXI

MIXTURES FOR BREEDING PIGS

A	B
30% Maize meal.	20% Maize meal.
30% Tapioca flour.	20% Tapioca flour.
15% Dried sugar-beet pulp.	20% Dried sugar-beet pulp.
10% Bean meal.	38% Bean meal.
15% Fish meal.	2% Sterilized steamed bone flour.

The value of some of these feeding-stuffs will be separately discussed in the part of the chapter which deals with the feeding of fattening pigs.

When cereals, especially wheat, have been very cheap, rations in Table XXII have been fed with success to sows:

TABLE XXII

MIXTURES FOR BREEDING PIGS

		A	
Barley meal ..	30%	Bean meal	20%
Wheat meal ..	20%	Fish meal	10%
Weatings	20%		
		B	
Barley meal ..	25%	Fish meal	5%
Wheat meal ..	10%	Linseed cake meal	3%
Maize meal ..	15%	Chalk	1½%
Bran	10%	Salt	½%
Weatings	30%		
		C	
Barley meal ..	20%	Linseed cake meal	10%
Wheat meal ..	15%	Soya-bean meal ..	10%
Maize meal ..	20%	Chalk	1½%
Weatings	23%	Salt	½%

It will be noticed that the quantities of weatings have been reduced when wheat has been included. This change reduces the cost of the ration with most prices prevailing for wheat and weatings.

If sows are housed they will benefit from being fed on green foods such as kale or cabbages; if these are not available, lucerne meal, mangolds, and potatoes may be given (the latter will pay for cooking if this can be arranged conveniently). Natural, succulent foods are always beneficial to pregnant stock especially as the time of parturition approaches, but when prices of carbohydrates are high it is possible to feed roots as substitutes for cereals, 8 to 10 lb. of mangolds or 3·4 lb. of cooked potatoes being equal to 1 lb. of barley meal.

Sows should be placed in their farrowing quarters some 7 to 14 days before farrowing is expected (the longer time being allowed for gilts farrowing for the first time). In various parts of this country sows are now farrowed, and piglings are reared, under different housing systems; in order to understand the feeding problems it is essential to mention some of the most common methods of rearing that are in existence.

(*a*) Farrowing pen completely under cover in old-fashioned piggeries or modern Danish houses, both the sow and her progeny remaining housed till weaning time. In older houses earth or rammed chalk was the flooring material, but in the modern piggeries harder material such as concrete is used—often with a false wooden floor for a bed during cold periods.

(*b*) As (*a*) except that the little pigs (sometimes alone and sometimes with the sow) run out in the open daily, either to concrete runs, or to permanent earthen runs, as soon as the piglings are a few days old.

(*c*) As (*a*) except that the sow and her progeny are moved to fresh quarters when the little pigs are 10 days old (during warm weather), or 20 days old (during cold weather). The sow is either moved to other pens or yards where a number of sows and their progeny may be kept together, or the sow and her family may be moved to individual or group outdoor houses.

(*d*) Farrowing in a hut which is just big enough for a sow and her progeny and which is placed in a grass run $\frac{1}{4}$ to $\frac{1}{8}$th of an acre in size, that is permanently fenced. Where bigger huts and runs are used several sows will be running together as mentioned in (*c*). A further modification is to have temporarily-fenced runs.

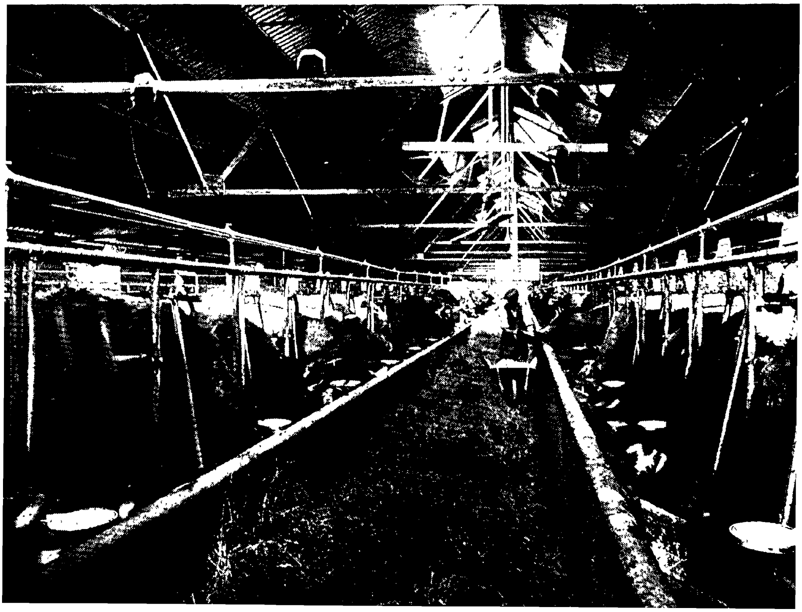
(*e*) As (*d*) except that the pigs are folded on arable land or on grass leys.

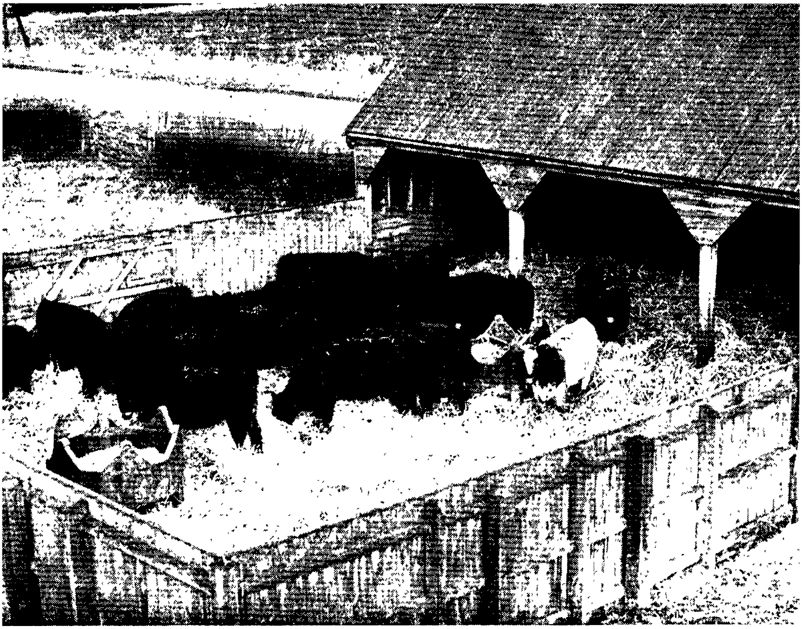
(*f*) Sows may be housed in huts with small pens attached to them (7 yards by 7 yards or even smaller) the whole unit being moved daily. Sows may farrow in such units, or they may be

Above : Feeding maize to cows on pasture.

Below : Cowshed : feeding hay concentrates, water and salt licks.

Photographs by courtesy of " The Farmer and





Above : Cattle in partly covered yard.

Below : Pens showing stanchions for calf feeding.

Photographs by courtesy of "The Farmer and Stockbreeder

Above : Arable land sheep : lambs "forward in the creep" eating hay and concentrates
Photograph by courtesy of "The Farmer and Stockbreeder"

Centre : Arable land sheep in lambing pen, showing water troughs.
Photograph by courtesy of "The Farmers' Weekly"

Below: Grassland sheep: ewes eating concentrates. Note the necessity for "creeps" for lambs.
Photograph by courtesy of "The Farmer and Stockbreeder."

Above: Mountain sheep showing poor grazing land in winter.

Photograph: Fox Photos

Centre: Grassland sheep receiving mangolds.

Photograph: Eric Guy.

Below: Mountain sheep showing poor grazing land in summer.

Photograph: The Times

Above : Tethered sows showing "Creep feed" for piglings, water tanks and troughs for sows.

Below Pigs folded on arable land.

Photographs by courtesy of "The Farmer and Stockbreeder."

Above : Pigs feeding on concrete runs.

Centre : Pigs feeding : troughs on concrete yard.

Below : Pigs fed in Danish type of piggery.

Photographs by courtesy of "The Farmer and Stockbreeder."

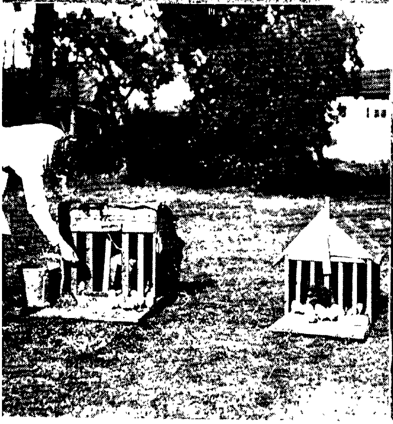
Top : Hay trussed to economise winter feeding.

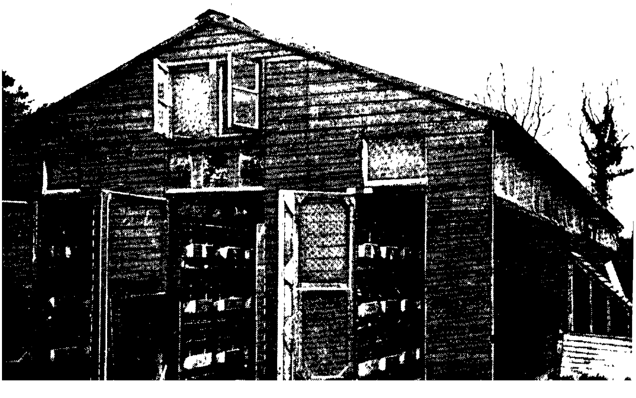
Photograph : J. Dixon Scott

Centre left : Mare and foal: mare teaching foal to eat from trough.

Centre right : Hay hauled out for cattle feeding on pasture in winter time.

Photograph : Eric Guy





Top: Laying hens: folding units on pastures.

Centre left: Rearing chickens in coops (old-fashioned system).

Centre right: Sussex arks for hens on pasture.

Foot: Laying hens: battery system.

moved to them after farrowing, as mentioned in (*c*). This may be done on permanent grass, temporary grass or even a root and cereal crop or stubble.

(*g*) Each sow may be provided with a hut, tether, harness and chain which must be so fixed that she can only get into her own hut, but it must be so far from all other sows that no two sows can reach one another and fight. It must not be forgotten that a sow will not settle if she is the only animal put into a field and no other pigs are in sight. Sows may farrow all the year round in these huts in the South of England, but farther north in cold weather they are usually farrowed elsewhere, and moved to the tether as mentioned in (*c*). Tethering is usually carried out on temporary or permanent grassland.

It would take too long to discuss all the possible systems in detail, but in general terms it may be stated that little pigs thrive best if they live as much as possible out of doors in sunlight where they can eat green food, provided the land is free from internal parasites and from diseases. One of the worst troubles that beset pig-breeders is anæmia and that usually disappears as soon as little pigs live almost all their lives on pasture. If it is essential to house sows and suckling pigs then, if possible, they should receive green food—if that is impracticable then lucerne meal should be incorporated into the sow's ration as soon as she is housed for farrowing. Opinions vary, but experts think that 2 to 5% of the concentrated ration should be lucerne meal.

As the time of farrowing approaches and the sow's udder is most definitely full (thus giving a sign that farrowing is about to take place) it is essential to see that she receives a laxative ration, and for this purpose bran mash is recommended; this may be made by pouring hot water on bran, and then leaving it to cool for half an hour before feeding. (If hot water is not available cold may be used), but warm water produces the better results. The quantity of bran that may be fed is as much as the sow will eat, which may be 8 or 10 lb. of the bran before soaking. As soon as farrowing commences the sow will usually eat nothing for a period of 12 to 24 hours, depending on the duration of farrowing. Bran mash is the best food for her for the first forty-eight hours after farrowing; the next step is to change over gradually to a normal mixture which may be the same as that given on page 262. Some feeders object to using fish meal, more on principle than because it is harmful when fed to sows; it is therefore necessary to give a ration where fish meal is omitted and also where only a small proportion is included.

TABLE XXIII

MIXTURES FOR SOWS, WITH LITTLE OR NO FISH MEAL

A	B
20% Barley meal.	50% Barley meal.
20% Sussex ground oats (or finely ground oats).	20% Fine weatings.
38% Fine weatings.	20% Bean meal.
10% Linseed cake meal.	5% Decorticated ground-nut cake.
10% Soya bean meal.	5% Fish meal.
2% Minerals (1 Part Sterilized steamed bone flour, 1 Part finely ground chalk, ½ Part Common salt).	

Some breeders feed a mineral mixture similar to that given above whenever the quantity of fish meal fed falls below 10% of the ration. The importance of calcium in the mineral mixture cannot be overemphasized, especially if breeding sows are housed, because deficiencies lead to a reduction in the number of pigs per litter, low milk yields from sows, and, in extreme cases, sterility, and deaths of sows. A suckling sow is said to require 2 oz. of lime (CaO) daily, and if a sow's ration contains 1 lb. of fish meal then it alone contains 1·6 oz. of lime and the remainder of the ration will always supply all that is required. A small quantity of chalk is beneficial, but excesses are detrimental, again 1 lb. of fish meal is all that is required. A mixture that has been widely recommended when fish meal is omitted is 4 parts of finely ground chalk to 1 part of salt, fed at the rate of 1 oz. of the mixture daily, when sows are dry, which must be raised to 2½ oz. when the sows are in milk. Charcoal or coal may be given to housed sows once a week to provide them with something on which to grind their teeth; it appears that the coal seems to aid digestion.

It is common complaint that sows have insufficient milk for their piglings; this may be because of faulty feeding during pregnancy, e.g., by giving an excess of carbohydrates and by feeding constipating rations. Occasionally, even when sows have been fed properly a sow seems to have little or no milk for her pigs, the latter following their mother about continuously screeching for milk; it is a pitiful sight. If a number of sows are farrowing within a short space of time it is possible, if a sow dies, or if she farrows down with little or no milk, to transfer her piglings to other sows that may have plenty of

milk and too few piglings. Such additions should be made as soon as possible after a sow has farrowed, for she quickly becomes familiar with her own litter and also with its size. If the orphan pigs can be added while the pig is actually farrowing then she will usually accept them with the minimum of trouble. Similarly, if litters are very large it is often necessary to transfer a few pigs to other litters in the manner described above. General experience is, however, that good medium-sized litters, i.e. 8 to 10 pigs, thrive better than do litters of 12 or more pigs, and some breeders cull sows that invariably have exceedingly large litters almost as surely as they do sows that have very small ones, because with very large litters some piglings are weak and many losses generally occur.

It is difficult to give piglings milk from a bottle, or from an "artificial sow," and an attempt must be made to stimulate production in the sow if she has little milk unless her piglings are old enough (at least six weeks) to drink from a trough; then weaning the piglings is the best step that can be recommended. When a gilt or sow farrows down and has little or no milk, attempts may be made to stimulate milk production by giving her very wet rations of whole cows' milk, lime-water, cream and milk sugar, together with natural succulent foods. Occasionally a sow may be unable to produce sufficient milk for her pigs because she is given too little water; experimental work shows that suckling sows require 4 to 5 gallons of water daily while on pasture, and there are big variations from sow to sow and from day to day, some sows consuming up to 10 gallons of water daily.

Sometimes when sows are housed, breeders give them cod liver oil in their rations, particularly during the winter time; it seems that ½ oz. daily will provide the vitamins required. Also the presence of adequate supplies of vitamins should ensure better utilization of calcium that may be supplied in the ration.

The next problem that frequently besets pig breeders who keep their sows housed most of the year round, is anæmia, which is characterized by severe scouring in the little pigs and subsequent unthriftiness; this trouble rarely, if ever, occurs when sows and their progeny are running on pasture, with one of the outdoor systems described earlier in this chapter. Some farmers have been forced to change to the outdoor system of rearing because of the troubles they have experienced with anæmia with indoor rearing. When the trouble appears several remedies may be tried if anæmia is suspected, e.g., a sod or turf roughly one foot square may be dug at weekly intervals and placed in the sow's pen (this will not produce

the desired results if the soil is deficient in iron), or a solution containing iron may be painted on the sows' teats several times daily and always before a suckling time. A mixture* that has been recommended for this purpose is:

3¼ oz. Anhydrous ferric sulphate.
¾ oz. Copper sulphate.
1 pint Hot water.
1 pint Feeding treacle.

The above mixture contains copper because that plays a part in the assimilation of iron; this is evidenced by the recommendation that the following mixture may be placed in the piggery for suckling sows:

1 cwt. Soil.
1 lb. Iron sulphate.
4 oz. Copper sulphate.

These recommendations all assume the trouble occurs in the piglings when they will take nothing but sow's milk; if on the other hand the piglings are a little older medicines that contain readily available iron compounds may be mixed with their rations. Another possible cause of scouring may be that the piglings receive more milk than they can digest; this may be corrected by reducing the quantity of succulent foods given and by shutting the piglings away from the sow for a period during each day, i.e. there would be partial weaning.

Sows should be fed liberally while suckling average, or big, litters, because not only is it necessary to produce ample nutrients for milk production, but it is essential to see that the sow does not lose too much condition during suckling otherwise she may not come on heat again quickly after weaning. It must not be thought, however, that sows must not lose any condition whilst suckling, because that is not so; actual quantities of concentrates fed may easily reach 16 lb. daily by two weeks after farrowing, and, when large litters are being reared, this figure may be as high as 20 lb. daily. If a sow is grazing and there is a good supply of grass each of the above figures may be reduced by 4 or even 6 lb. of meal daily. This level of feeding must be maintained till the litter is weaned. Then, to arrest milk flow, a sow should be put suddenly on to a scanty ration and preferably in a bare pasture where she can get plenty of exercise but very little food. As soon as her milk production ceases and her udder collapses she may be fed on the normal ration for dry sows that has been described earlier.

* Little pigs may be dosed individually with such a mixture.

In cold exposed areas sows farrow only once a year, mainly in the spring, because the little pigs thrive so well in the warm spring air, but in many districts the aim is for all sows to farrow twice a year. The ideal arrangement is for the herd of sows to be divided into two groups, those in one group farrowing in February and again in August, and those in the other group farrowing in May and November. In theory this means that the farrowing pens are used almost continuously and the fattening pens are kept more or less full; in practice sows do not have two litters a year with clockwork precision, but they have two litters in thirteen or fourteen months. This loss of time generally means that one batch of sows overlaps the next and consequently congestion occurs in the farrowing pens and later in the fattening quarters., It seems, however, that less time is lost between one farrowing and the next when sows are fed properly balanced rations that contain sufficient proteins and minerals. Deficiencies in calcium and proteins are characterized by delayed appearance of heat periods, after weaning, until the deficiencies in sows' bodies are remedied; also these deficiencies lead to reduced litters when breeding recommences. The feeding of the sow calls for careful supervision at all times but especially where litter sizes are small. It does not always follow, however, that small litters always mean faulty feeding; it may be hereditary trouble because it is well known that size of litter is inherited, and that by breeding from the right strains of pigs the number of pigs born per litter may be increased.

Pig keepers always find that when little pigs are born at all times of the year, those born in the spring thrive better than those born in the autumn. Pigs born during the months of November, December, January and February make slow growth and are often fully one month longer in attaining bacon weight than those born at other times of the year. Farrowing in these months is always attended by more losses at farrowing time and also from farrowing till weaning, but if the aim is to obtain even output from the sows, breeding must continue throughout the year and especial care must be taken of the sows and their litters when they farrow in mid-winter. Sows must be housed in warm buildings, or they must be given artificial heat, at farrowing times. This does not mean that farrowing on the tether is impossible in mid-winter, but that there is a case for hanging a lamp, e.g., a miner's lamp, high up in the hut at farrowing times; this has been shown to afford sufficient heat for the sow and her pigs. If sows are in piggeries it is a good policy to put down a false wooden floor, over a concrete floor, to make a warm bed, and then to put a false straw roof over the pen at the height of about three

feet; this will make a warm pen even in a cold piggery. It may be worth while giving a sow a warm mash at farrowing time when the weather is cold. Another way in which it may be possible to reduce mortality in pigs is to feed the piglings liberally with good foods, and in cases where it is available, a little skimmed milk (dried skimmed milk moistened will do), given warm, may help little pigs in cold weather. Such food will be given to little pigs in creeps as described below.

As soon as piglings are three weeks old they should be given a special ration to themselves; for convenience it is usually desirable to give such rations in creeps away from the sows. Modern opinion on pig-keeping is that the best results are never obtained with the piglings unless they are fed separately from the sows. Various devices are found in practice to feed special rations to piglings, namely:

(*a*) Troughs which are fitted with bars through which piglings can feed; the bars are put so closely together that sows cannot feed. These may be used on pastures, in yards, or in farrowing-pens.

(*b*) Small doorways may be made in pens so that little pigs only may go outside for their concentrates.

Various feeding-stuffs may be given as this first ration for little piglings; some breeders give rations consisting entirely of fine weatings, but this is gradually changed to 90% weatings and 10% fish meal by the time the piglings are ready for weaning; other breeders use complicated mixtures in Table XXIV.

TABLE XXIV

MIXTURE FOR WEANERS

25% Flaked maize.
63% Fine weatings.
10% Fish meal.
2% Lucerne meal.

When little pigs first start eating their own ration of meal they eat very little, but the quantity consumed daily will increase so that by the time of weaning little pigs will often be consuming 2 lb. per head daily. It is most important that piglings should be given special rations because (*a*) they thrive better on certain foods, (*b*) they need to eat small quantities of food and at frequent intervals; a creep allows them to do this, whereas if they have to share the sows' ration she eats it up rapidly and so the piglings must feed when she feeds

or they get nothing, (*c*) if by any chance the litter is large, or the sow has little milk, the piglings will benefit particularly well from the extra nourishment that is provided, (*d*) since the piglings are eating solid food before weaning they feel the check of weaning much less than would otherwise be the case, and they will feed much better after weaning if no change is made in their ration. It is essential that piglings should make rapid live-weight gains during suckling and when they are very young, because gains are then made at a lower cost per unit of food consumed; it has also been shown that for meat production better proportioned carcases are obtained if pigs grow rapidly when young.

Till just after weaning all pigs in any one herd are fed the same whether they are intended for breeding or fattening; the parting of the ways arrives shortly after weaning; gilts required for breeding are often fed on store rations rather than on that given to the fattening pigs. It is very doubtful, however, whether it is sound to select little pigs for breeding for bacon production when the pigs are themselves only 8 or 10 weeks old, it appears to be much more sensible to select gilts for breeding when they have attained bacon weight; then one can see whether they are of the lean type for bacon or the short thick-set type for pork. It is difficult to see that any harm can arise from selecting gilts for breeding out of the fattening-pens; it is well known, however, that if breeding gilts are selected when piglings are 2 or 3 months old many do not develop properly, and at least two gilts must be selected for each one required for breeding, in order to allow for culling. With boars similar disappointments will occur but the situation is quite different because castration is best carried out when piglings are still suckling, i.e., when they are only 6 weeks old. If castration is delayed the actual operation is more difficult and it produces a greater check to the animal concerned. Thus boars for breeding are separated at weaning time from their litter-brothers and sisters and fed separately, either by running several boars together or, if only one boar is saved from a litter and no other boars are of the same age and size, it may be necessary to provide the boar with a castrated hog-pig from the same litter for companionship. Young boars are usually fed very well, often with milk after weaning, either liquid or in some dried form, since they are often required to make good live-weight gains; if they are for sale it is essential that they are from quickly-maturing stock.

Mixtures of concentrates that give ratios of S.E. and P.E. that are 4 or 5 to 1, are usually satisfactory for breeding pigs of all classes and ages, but the exact requirements are not precisely known. In the

TABLE XXV

MIXTURE FOR YOUNG BOARS

	S.E.	P.E.
25% Barley meal	17·8	1·83
20% Flaked maize	16·8	1·84
20% Fine weatings	13·7	2·52
20% Bean meal	13·2	3·94
10% Fish meal	5·9	5·30
5% Dried separated milk	3·9	1·55
Total	71·3	16·98

Ratios of 4·2:1

above ration dried skimmed, or rather separated, milk is included because quick live-weight gains are required and it is well known that milk products will certainly give this required result; dairy products are often too expensive for inclusion in the rations of ordinary stock that are being reared. As regards quantities of concentrates the aim with boars is to induce them to grow and it is unusual to limit them at all. Actual quantities fed may be as for baconers, namely, at least 1 lb. of meal for each 20 lb. of live weight of pig till 100 lb. is reached and then the quantity for each subsequent 20 lb. will be ½ lb.; thus a pig at 200 lb. will be receiving at least 7½ lb. of concentrates. To obtain good development such a boar should run out on grass, provided that the land is not stale from pigs and laden with internal parasites. After 200 lb. live weight is reached the quantity of concentrates will be increased gradually but no set figure can be given except that many mature boars live quite well, and breed satisfactorily, on 8 lb. of meal per day when receiving no other food whatsoever.

There can be no doubt that the most difficult period in the rearing of a pig is that shortly after weaning. In many cases it seems that at such times pigs will not thrive, and they make little or no growth; on the other hand by the time they are 80 to 100 lb. in weight they will usually grow very rapidly. Knowing the difficulty that usually arises with young pigs, it is a wise precaution to treat them for worms immediately after weaning, because such treatment cannot give satisfactory results whilst piglings are suckling their dams. This is because efficient treatment for worms requires that pigs shall be fasted for 24 hours and this, whilst suckling, might make a sow go dry. Various powders and fluids may be given pigs to remove worms from their digestive tracts. The two chief ways are, however, either to dose each pig individually or to mix the oil or powder into the

ration, and since all the pigs have been starved for 24 hours previously they will eat this ration freely; it is quite obvious that some will receive more of the vermifuge than others. The first part of the treatment is to partially poison the worms and the second part is to force them out of the pigs' systems; this is accomplished by giving castor-oil or some similar medicine when the first food is given, or, in some cases, actually with the worm poison. One of the best liquids that can be used for pigs is 5% of oil of chenopodium in 95% castor-oil. actual quantities given depending on the size of the pigs. During the worming process the pigs should be kept housed on concrete floors so that any worms that are expelled may be swept up and destroyed. If the pigs are running out on pasture, fasting is impossible and all of the parasites that have been expelled cannot be collected. After the de-worming feeding may proceed normally.

In view of this difficult period in the life of a pig many farmers give the same ration continuously from before weaning till the pigs are 90 lb. in live-weight; this is usually expensive, but it is a certain way of making the little pigs thrive, provided a well-balanced ration is being given. The feeding of one ration throughout the period also reduces the possibility of checking the pigs by changing from one ration to another. If little pigs are housed in winter it is worth while considering adding a little cod liver oil to their rations to assist them in assimilating calcium, which tends to prevent the appearance of rickets. Whenever it is available, green foods, in moderation, given to housed, freshly weaned piglings will be advantageous as an insurance against mineral deficiencies.

The housing of piglings just after weaning is often a problem but provided the weather is suitable, and the pigs have been reared in the open air, there is no doubt that they will thrive better if they remain on pasture than if they are taken into buildings at that time. Practical men state that piglings suffer a severe check if they have been reared out of doors on pasture and are then suddenly weaned and housed. This involves four big changes in the pig's life, namely, loss of milk, loss of sunlight, loss of grass and loss of exercise; these sudden changes lead to unthrifty piglings. The best place for pigs, that have been reared outside, is on grass until they are 80 or 90 lb. in weight, but this does not mean that the same runs should be used continuously because they will become very heavily laden with internal parasites. No grassland should be used continuously for pigs for more than six months, and it is very doubtful if the same land should be used again for pigs till a period of two years, some say four years, has elapsed. While running at grass the piglings should be put into

big groups numbering 50 to 100, because this will reduce feeding costs, and it will facilitate selection of uniform pigs for fattening. Such pigs will require one large shed, or shelter, into which they may return for the night. The pigs should be fed mash twice daily, and have a sufficiency of dry meal and a supply of water constantly before them. Some breeders may be nervous of having such pigs on grass during the winter, but there is no doubt that it is quite safe, in many districts of this country, and certainly in the South of England. A further advantage that may be derived from running pigs at grass is that they develop their muscles better than if they are housed, and this in turn results in their producing a leaner carcase when they are ultimately fattened; this seems to be quite sound reasoning, in support of which it might be urged the higher quality of the outdoor pigs as demonstrated when pigs were being sold on a grade basis.

If by any chance the piglings have been reared indoors, then it will be fatal to turn them out to grass during the winter, but it may be well worth while during the summer. During the winter the cheapest and most satisfactory way of housing such pigs is in large yards; it is important, however, to make provision for the little pigs to sleep in warm dry sheds or under some cover. When kept in yards it is quite a common practice to provide the piglings with two feeds per day of moistened meal (possible in a dining-room), and to leave a self-feeder containing meal, and also a supply of water constantly before them. Self-feeders are even more important here than for pigs out at grass, because the latter can eat grass between feeding-times, whereas pigs in yards can eat nothing. There is no doubt that the self-feeder will enable the piglings to make far better live-weight gains than will be the case if none is provided.

The next, and last, phase of the feeding that must be considered is the fattening phase which will depend on the market for which the pig is being prepared. It is therefore necessary to give the ages and live weights at which pigs are sold, namely:

London Porkers	weighing	90 lb.	at 4 months.
Cutters	,,	140 lb.	,, 5 ,,
Baconers (Wiltshire)	,,	200 lb.	,, 6 ,,
Birmingham Cutters	,,	300 lb.	,, 7½ ,,

Fat sows weighing up to 1,100 lb. at maturity.

For the small-pork trade it is most desirable to feed pigs upon milk by-products, e.g. skimmed milk or whey; several gallons of milk products may be given daily, or these products may be used to

moisten the concentrated rations. There is no doubt that the feeding of rations moistened with milk leads to wonderful growth in the piglings receiving them. Experimental work suggests that 3½ lb. of milk, or 6 lb. of separated milk, or 12 lb. of whey are equivalent in food value to 1 lb. of cereal meal, and that substitution may be made on that basis. It is recommended that the following rate of feeding separated milk, either fresh or reconstituted from the dried product, should be followed for pigs aged 8 to 12 weeks, 4 to 6 lb, of separated milk for each 1 lb. of meal; aged 12 to 18 weeks, 3 lb. of separated milk for each 1 lb. of meal; and for pigs aged 18 to 30 weeks, 2 lb. of separated milk for each 1 lb. of meal. If no such dairy products are available substitutes may be supplied in a mixture as in Table XXVI.

TABLE XXVI

A MIXTURE FOR SMALL PORKERS

	S.E.	P.E.
	lb.	lb.
30% Barley meal	21·4	2·19
30% Flaked maize	25·2	2·76
20% Fine weatings	13·7	2·52
10% Bean meal	6·6	1·97
10% Dried skimmed milk	7·9	3·09
Total	74·8	12·53

It will be observed that the ratio of the ration is just under 6 of S.E. to 1 of P.E., and it might be added that the ration may contain a ration of S.E. to P.E. up to 7 : 1. Fish meal has been omitted from the above ration purposely because many purchasers are afraid to buy pigs that have been fed upon fish meal because of the alleged risk of taint. The above ration could be fed during the suckling period, and throughout the pig's life till it is sold fat for the small porker market. The quantity of ration fed daily will be about 1 lb. for each 20 lb. of live weight; some feeders may give even slightly more than this allowance. For the small-pork trade certain kinds of pigs are required, and they are characterized by their short, thick-set type of the Middle white or Berkshire breeds; they must be fed liberally during suckling periods if they are to be sold at young ages for pork.

Many of the breeders who are producing cutters do so more by accident than by design, for many of these pigs are those that are really intended for the bacon trade, but were developing rather the short and thick-set type as opposed to the long lean type required for

bacon. Thus many cutters are reared on baconers' rations, and it seems unnecessary to give separate rations for cutters and baconers. By the time pigs reach the age of 90 lb. they are usually put into their fattening quarters, if that has not already been done. Without a doubt, housing plays a big part in the efficiency of food utilization during the final stages of fattening, for, under good warm conditions, some pigs will make 1 lb. live-weight gain for every 2½ or 3½ lb. of meal consumed, whereas under bad conditions fully sometimes 5 lb. more may be required for each 1 lb. of live weight gained. An increase of 1 lb. of meal for each 1 lb. of live weight gained takes about 1 cwt. of meal extra for each fattening pig; this, depending on prices, represents a cost of 7s. to 10s. per pig. Usually fattening in warm piggeries of the Danish type leads to the most efficient food utilization, providing appropriate rations are fed. For the fattening period it is possible to put the pigs into pens, at the rate of 10 per pen (as is usually done in the Danish houses), or the pigs may remain in yards till they are almost fat; in these cases it is usually found desirable to move the pigs into small pens for the last month of fattening.

Before any actual rations are considered, it is necessary to discuss that very debatable question, whether the aim should be to fatten the pigs at the maximum speed possible by giving them as much food as they will eat, or whether feeding should be restricted. The results of experiments on the question are rather confusing, but the general concensus of opinion seems to be that feeding *ad lib.* leads to quicker fattening, to inefficient food utilization and to a carcase that is too fat to be of the best quality for bacon production. It appears, however, that the general statement does not apply to all breeds and even to all families within certain breeds. There is no doubt, however, that many breeders give fattening pigs too much food, as is evidenced by the fact that sometimes final rations may consist of 9 lb. of meal, whereas some breeders obtain quite satisfactory results from feeding a maximum of 5½ to 6 lb. of meal. Before leaving the question of restriction of food it might be mentioned that some farmers do not feed any of their pigs for the one half day in each week when their respective pigmen have their half-day holiday. Sometimes extra food is given during the morning after the fast, but more frequently no extra food is given. By this means, therefore, one feed is saved of the fourteen normally given per week, and the only experiment which has been conducted on this point, and with which the authors are familiar, indicated that this one fast of a half-day per week did not lead to any loss of live-weight gain. It may, therefore, be very convenient to omit feeding pigs on the pigman's half-holiday.

During the final stages of fattening for bacon, considerable liberties may be taken in the feeding stuffs used, for after a pig reaches 90 or 100 lb. live weight it will thrive on foods that previously produced little or no growth. This does not mean that suddenly big changes should be made in the feeding, but that gradually the cheaper foods can be introduced, and given in relatively large quantities by the time the pig is eating concentrated foods freely. Where prices are suitable there is no better food than barley for the fattening pig and it is quite safe and common for 75% of the fattening ration to be barley meal. The famous ration that has been recommended for fattening pigs is the 65–25–10, which being translated is in Table XXVII.

TABLE XXVII
A MIXTURE FOR BACON PIGS

	S.E.	P.E.
	lb.	lb.
65% Barley meal	46·4	4·75
25% Weatings	17·1	3·15
10% Fish meal	5·9	5·30
Total	69·4	13·20

Usually one month before the pig is ready for killing the percentage of fish meal is reduced to 5% and the quantity of barley meal correspondingly increased to 70%; two weeks later the ration is further modified as in Table XXVIII.

TABLE XXVIII
FINAL MIXTURE FOR BACON PIGS

	S.E.	P.E.
	lb.	lb.
75% Barley meal	53·6	5·48
25% Weatings	17·1	3·15
Total	70·7	8·63

There is no doubt that these rations are the simplest and safest that can be fed, provided good qualities of food are used, but, whenever barley meal is expensive substitutes are sought. Some cereal meals may replace barley meal, e.g. maize, wheat and rye, but not large quantities of oats, because of their high husk (hence fibre) content. Maize is widely used as the main constituent of the rations of fattening pigs, but there is always the danger that if it is used as the

sole cereal in the fattening ration it may seriously reduce the quality of the resulting bacon, because of the soft oily fat produced. This oily condition is not so unpopular in some countries as in this; here maize products should not exceed 40% of the ration. Maize may be used in the flaked form, as meal, or in both forms in the same ration. Wheat and rye are not safe for feeding in such large quantities as 65% of the total ration, though either of these cereals may be used as about 20% of the total ration; if both are used the remaining 25% may be barley meal or maize meal.

Another way of replacing the barley meal is by using imported carbohydrates, such as tapioca flour, or possibly sago pith meal; these feeding stuffs are not always available, but they appear on the English market whenever prices of carbohydrate foods are high, for when prices are low costs of transport are too high to make it worth while bringing these feeding-stuffs to this country. These carbohydrate foods are rather fibrous and unpalatable and should not be used liberally in a ration. It is very doubtful if both should be used in one ration; when used separately the quantities should not exceed 40% tapioca flour and 20% of sago pith meal. There is some experimental evidence that the use of tapioca flour assists the quality and colour of bacon fat.

TABLE XXIX

MIXTURES CONTAINING TAPIOCA FOR BACON PIGS

I	II
40% Tapioca flour.	25% Tapioca flour.
20% Maize meal.	20% Maize meal.
20% Flaked maize.	15% Flaked maize.
12·5% Weatings.	20% Weatings.
5% Fish meal.	13% Barley meal.
2·5% Lucerne meal.	5% Fish meal.
	2% Lucerne meal.

Another carbohydrate food that is usually available at a relatively low price is dried sugar-beet pulp; this is rather a fibrous food and is unsuitable for feeding to young pigs, but it may be fed with care to pigs over the age of 3 months, i.e. about 60 lb. live weight, to a maximum of 20% of the ration. The use of dried sugar-beet pulp in a ration does not affect the rate of live-weight gain made by the pigs, and it can be advantageously used whenever it is available at the cost of £1 per ton less than barley meal. Since the sugar-beet industry has established itself in this country, it has been worth while to use

dried sugar-beet pulp in the rations of fattening pigs, but many pig feeders will not use the pulp. On account of the fact that dried sugar-beet pulp swells very markedly when moistened it is desirable to feed mixtures wet, whenever the dried sugar-beet pulp is included amongst them.

Occasionally wheat sells at a relatively low price and since it is a home-grown food farmers often wish to include it in the rations of fattening pigs. A simple way of doing so is to use one of the following basic rations for pigs after weaning and then as fattening proceeds to add the high carbohydrate supplement as shown in Table XXX.

TABLE XXX

WEANERS' BASIC MIXTURES

X	Y
50% Weatings.	60% Weatings.
15% Barley meal.	10% Barley meal.
10% Wheat meal.	10% Wheat meal.
13% Maize meal.	10% Maize meal.
10% Fish meal.	10% Fish meal.
2% Lucerne meal.	

Both weaners' rations to have 1 part Chalk, 1 part Salt, 1 part Charcoal, at the rate of $1\frac{1}{2}$ parts per 100 parts of X or Y.

Pigs should first be fed on X or Y and add Wheat meal 1 part and Barley meal 3 parts mixed (or Barley meal entirely, or Barley meal 1 part, Maize meal 1 part) in that ration, so that final fattening ration becomes 50% Mixture X or Y plus 50% cereal supplement. This provides a flexible rationing system and enables one to utilize whatever cereals are cheap, or are available in large quantities.

In recent years two new carbohydrate foods have appeared on the market in the forms of dried potato flour and potato flakes; from their analyses they appear to be equal in food value to barley meal, and unless some special properties are discovered there seems to be no reason to pay higher prices per ton for them than is paid for barley meal.

For years it has been the policy on farms in the potato-growing areas of the country to feed potatoes to fattening pigs. As has already been mentioned in this chapter, 4 lb. of raw potatoes are equivalent in food value to 1 lb. of barley meal; for fattening pigs over 100 lb. live weight a maximum of 8 lb. of potatoes may be fed daily, and a corresponding deduction must be made in concentrated

foods. To obtain the best results the potatoes should be fed cooked (1 lb. cooked being equivalent to 1·34 lb. raw) and, where it can be conveniently arranged, given to the pigs mixed with the meals, while still warm. Where no potatoes are grown but where roots are available they may be given instead (but cooking is not usually done); it must be remembered, however, that mangolds have only half the food value per pound of that in the raw potato, and corresponding adjustments must be made in the rationing.

During the summer, grazing may, in some circumstances, be used to reduce fattening costs, for it has been shown that a fattening pig will eat a certain amount of grass. By the time a pig reaches bacon weight he may be eating as much as 14 lb. of grass daily, which will be equivalent in food value to 2 lb. of dry meal. It is not usual to fatten pigs on grass in this country, but it is well known that many bacon pigs are fattened on the pastures of New Zealand where their diet consists of nothing but grass and skimmed milk. This seems to be a queer mixture to those who farm in this country, but it is even more amazing when one hears that the pigs, while being fattened for bacon in New Zealand, may drink up to 20 gallons of skimmed milk daily during the final stages of fattening. Those who have had no experience of this system of feeding might expect profuse scouring to occur, in actual fact no such trouble appears. It seems that without a doubt a combination of grass, and an abundant supply of skimmed milk will under the conditions prevailing in New Zealand, fatten the pigs quite satisfactorily.

Mention of skimmed milk naturally turns the attention of the reader to Denmark, where it is well known that skimmed milk also figures prominently in pig rations; there it is not usual to feed such large quantities of skimmed milk daily, because relatively more pigs are kept and such large quantities are not available for feeding. In Denmark the skimmed milk, which is returned to the farmers after it has been pasteurized, is used as the main protein part of the ration in conjunction with a mixture of cereals, such as 2 parts of barley meal, 1 part of wheat meal and 1 part of maize meal for housed fattening pigs. It will be observed that a ration such as this provides less protein than will be found normally in a ration given to fattening pigs in the British Isles. This raises the very debatable question of whether the quantities of proteins that are commonly fed in this country are really required. This cannot be answered at the moment but experimental work is proceeding; it seems, however, fairly certain that the nature of the amino acids that are present in the protein must not be forgotten, and that it is more than likely that pigs can

utilize the amino acids that are present in skimmed milk, far more effectively than they can utilize the protein of fish meal, meat meals and possibly bean meals. It is well known that milk is designed by nature for consumption by young animals who have weak digestive tracts.

Although skimmed milk is not available on many farms in this country, whey is quite commonly available in some districts. In these cheese-making districts it is usually stated that there must be at least one cow to every fattening pig; a pig can consume up to 6 gal. of whey daily, and it is expected that this quantity of milk will produce 1 lb. live-weight gain daily. It is apparently necessary, however, to reduce this amount of whey fed to 1½ gal. daily by a fortnight before killing is expected, and then whey-fed pigs will produce as good carcases as those obtained from ordinary meal-fed pigs.

Although many pigs are fattened indoors, where they receive no green food, there is some experimental evidence which shows that the addition of a small quantity of green food to the ration of fattening pigs produces more benefit than would be expected from the quantity of nutrients supplied by that green food. It is suggested that a pound or so of green food supplies vitamins which are essential for the most efficient growth and fattening. Kale is a food that is available over a long period of the year, but it is very doubtful (except in war-time) whether it is worth while growing the crop especially for this purpose. Some feeders always supply a small proportion of lucerne meal in the rations of fattening pigs; this may supply the essential vitamins and so save the necessity of providing a supply of fresh green food daily.

Practical men find that, when fattening in houses on concrete floors, benefit is gained from giving pigs a weekly allowance of fine coal; this is given to the pigs one day each week at the rate of ¼ lb. per pig, and it will be observed that all pigs enjoy grinding their teeth on it, and they will consume this quantity readily each week. The coal seems to aid digestion and so keep the pigs healthy.

Some bacon factories have had bitter experiences in the past (owing to taint) from pigs that have been fed on large rations of fish meal, especially if this had been of an inferior quality; with the result that they now refuse to accept pigs for slaughter if they have been given any fish meal, and they require their suppliers of pigs to guarantee that the pigs have had no fish meal. There is no doubt the antagonism to fish meal is quite unjustified if moderate rations of good-quality meal are used. It is necessary, however, to give some rations that contain no fish meal.

TABLE XXXI

MIXTURE FOR BACON PIGS CONTAINING NO FISH MEAL

	S.E.	P.E.
	lb.	lb.
40% Barley meal	28·6	2·92
20% Flaked maize	16·8	1·84
20% Bean meal	13·2	3·94
20% Weatings	13·7	2·52
Total	72·3	11·22

Some feeders would consider that the ration should have a mineral mixture added; 1½ lb. of ground limestone or chalk and ½ lb. of ground salt to each 1 cwt. of food will provide all that is required.

TABLE XXXII

MIXTURE FOR BACON PIGS, CONTAINING FISH MEAL

	S.E.	P.E.
	lb.	lb.
20% Barley meal	14·3	1·46
20% Dried sugar-beet pulp	11·7	0·92
20% Flaked maize	16·8	1·84
15% Maize meal	11·6	1·14
15% Weatings	10·3	1·89
10% Decorticated ground-nut cake	7·3	4·13
Total	72·0	11·38

It is quite obvious that many other mixtures could be given but these will suffice to demonstrate that substitution to avoid using fish meal is quite easy, and that fish meal is not essential for the production of bacon pigs, as some feeders are inclined to believe.

No account of the fattening of pigs will be complete unless some mention be made of the feeding of hotel swill. Around most large towns of this country pigs are fattened on hotel kitchen refuse; pigs will thrive on such food provided that it does not contain relatively large quantities of salt, soda and such things as tea-leaves, which contain but little food value. The law requires that swill shall be cooked prior to feeding to reduce the risk of conveying diseases (especially foot-and-mouth disease) to farms. The main difficulty regarding the feeding of swill lies in its variable composition, for not only is it variable from one hotel to another, but also from day to day. Sometimes it may contain large proportions of meat, whilst at others it may contain mostly bread. It is impossible to supplement

swill with the proper nutrients to ensure adequate allowance of proteins and carbohydrates. The usual procedure adopted is to feed swill with meal (the protein content of which depends on the swill) and meal is used in sufficient quantities to ensure that the pigs are satisfied, this quantity can be ascertained by experience. Pigs may derive a maximum of two-thirds of their nutrients from swill during the final stages of fattening. Some bacon factories consider the use of swill leads to poor-quality bacon, which is likely to be displayed in the curing process by the fat on the back of the pig (or rather side of bacon) becoming separated into layers and thus making the cure to penetrate unevenly and so producing bad bacon.

Although the above rations appear under the heading of bacon pigs it must be pointed out that these rations are quite satisfactory for feeding to pigs for the North-country pork trade, and also to fattening sows. The only difference that will be made is that of quantity. Thus Birmingham cutters will receive up to 8 lb. of dry meal, or its equivalent, daily, and a fat sow will be given all that she can eat; this quantity may be 10 or 12 lb. per day, depending on the age and weight of the sow.

Although the pig of the past has been looked upon as a despised, neglected scavenger of the farm, that is no longer the case and provided the feeding is carried out with care the pig can not only clear up relatively large quantities of poor quality food, it may also turn it to profit. Profit must depend mainly on the efficiency with which the food is turned into live-weight gain. It must be stressed that the pigs of some families within a breed (and within a herd) are far more efficient converters of foods to flesh than are pigs of other families. The successful farmer is the one who discovers his successful families of pigs, breeds from them and culls the others.

XIV

FEEDING HORSES

ALTHOUGH much has been written on the mechanization of British Agriculture, horses are still to be found on farms in this country, not only for sport, but also for breeding and for work. On many British farms the horse is indispensable, and he will remain so on the smaller farms, especially where the acreage of arable land is relatively small. Without a doubt for the small farms the horse is more useful than a tractor, because he can do so many things, e.g. ploughing, hoeing, carting and breeding. As long as horses are wanted, breeding is likely to be a remunerative side-line for farmers, because if a brood mare works in addition to breeding, the cost of the foal is low, often being about £15 in many cases, whereas the actual value may be as much as double this cost. In addition to the ordinary heavy horses many lighter horses are kept on farms for hunting and also to provide hacks for townspeople. There is, apparently, a growing demand for light horses, and in consequence an increasing interest in the feeding of light horses.

For centuries horses have been used for draught purposes in countries with the cooler climates, but it is surprising to find that very little research work has been done on the feeding of farm-horses. It is difficult to understand why this is the case, because the horse appears to be an easy animal to handle experimentally; it is, on the other hand, difficult to measure the work done by a farm-horse and so to ascertain the actual food requirements.

In practice the feeding of working farm-horses is done very simply; in most cases the rations consist of hay, chaff and oats, and without a doubt excellent results may be achieved by feeding a combination of these foods. It is possible, however, to have disappointments when approximately orthodox rations are fed. In some years prices of one of the above feeding-stuffs may be high, so that changes are desirable to reduce feeding costs; it is necessary therefore to discuss the uses of alternative feeding-stuffs.

When hay is cheap there is always the temptation to feed it too freely; this may lead to no trouble in the majority of cases, but

occasionally it may give rise to shortness of breath in working horses, to quick tiring and to slow working. These small troubles will occur more especially when the quality of hay is poor, and especially when the hay is dusty. Many practical men emphasize that dusty hay leads to shortness of breath, possibly because of its effect on the bronchial tubes, and it is for this reason that with many horse keepers leguminous hays are unpopular because there is difficulty in making them satisfactorily free from dust. It is also well known that leguminous hays are inclined to be mouldy owing to the difficulty in carting the leafy hay in a dry condition; moulds are worse than ordinary dust in their effect on the wind of horses. When only dusty hay is available for feeding to horses it may be used with safety if it is fed moistened with water, that, as it were, lays the dust and makes the hay safe for feeding. For working horses the hard hays, i.e. those with relatively little leaf (and that usually means little legume) are considered to be the best. Rye grass is the most popular grass for hays for horses in this country, but abroad timothy often replaces rye grass in popularity.

The actual quantity of hay given daily will depend on the size of the horse, upon the amount of work being done, and also on the qualities of the foods being given. A very useful rule is that during periods of hard work about 1 lb. of hay be fed for each 1 cwt. of live weight of the horse. As many farms are not well equipped for weighing horses, it should be stated that many farm-horses weigh 15 to 18 cwt. and that it takes a large heavy horse to weigh 1 ton; some working horses may weigh as much as $1\frac{1}{4}$ ton, but such animals are very rare. When a horse is doing only light work it is possible to halve the amount of hay being fed (the actual amount depending on the amount of work being done), and to replace it by straw on a pound-for-pound basis; this is necessary to provide sufficient bulk to make the horse feel satisfied. It is possible to make slight economies in the hay ration by giving succulents in the form of mangolds, carrots and potatoes, but usually the foods replace cereals better than hays, because they are carbohydrate foods. During the summer time, however, many horses are at grass when they are not actually working; then it is possible to eliminate hay from the horse's ration because grass will replace it, except if a horse is left for a period in the stable waiting for another job. In a case of this kind a feed of hay will be placed in the rack, the quantity being only a few pounds.

A second form of roughage will be given to all farm-horses whenever they receive concentrated foods; this is chaff. Chaff may be made from hays or straws; frequently roughages that would not be

consumed in the ordinary way are chaffed and given to horses. It is very difficult to see that the horse can derive any benefit from eating such foods, other than that of utilizing the feeding stuff. The real object of giving chaff to horses is to mix it with concentrated foods to provide adequate material for chewing before swallowing. The chaff, therefore, is always fed mixed thoroughly with the concentrates. The actual quantity of chaff fed will be more or less constant at about 4 lb. per head daily throughout the year, whenever concentrated foods are being fed. Good chaff may be obtained from hay or from good oat straw; the latter is certainly very popular amongst horse keepers.

For many years the recognized concentrated food for the horse has been oats; this has become so traditional that many horse keepers refuse to use other feeding-stuffs. There is amongst horse keepers much conservatism regarding feeding concentrates other than oats to working horses. This is mainly pigheadedness and may be demonstrated by pointing out that Arab horses, which are famous throughout the world for their powers of endurance, are not fed on oats but on barley. In countries where maize grows freely it is the custom to feed maize as the sole concentrated food for working horses; the horses work and thrive well on this food. It appears, therefore, that working horses require plenty of carbohydrate feeding stuffs and that the source may not matter as much as many horse keepers believe. There can be no doubt, however, that oats are an exceedingly safe food, possibly on account of their high-fibre content, and there is very little, if any, risk of causing digestive disturbances by feeding oats to horses; this same statement is not true of all cereals. It must be remembered, however, that the feeding of any unripe cereals may lead to digestive disturbances, and that oats may produce such disturbances if fed too soon after harvest. If, however, the cereals are fed crushed, this treatment may often prevent the use of feeding-stuffs when they are unfit for feeding because if the grain is very unripe it will not pass through the rollers of a mill satisfactorily. The crushing of cereals must be strongly advocated to counteract the natural tendency of the horse to swallow foods unmasticated, if crushed grains are swallowed, without mastication, some digestion is possible because the inner portions of the grain will be exposed to the action of the digestive juices.

For average horses doing medium amounts of work, 1 lb. of oats are fed for each 1 cwt. of live weight; thus 14 lb. of oats is the standard ration for the average-sized working horse. When the work is light the quantity fed may fall to 10 lb. daily, or in summer-

time to 7 lb. daily, but with hard work the quantity may be increased to 18 lb. daily. Corresponding adjustments must be made according to the size of the horse. Substitutes for oats are discussed in the next paragraph; these substitutes may be used without affecting wind, endurance, or even the spirit of the horses eating them.

In this country complete replacement of oats is not normally necessary, but partial replacement is often desirable, for it may often result in a reduction of the feeding costs. It appears that protein equivalents of concentrates may be neglected where working horses are concerned, and only the carbohydrates need be considered. In the past farmers have made the mistake of replacing oats by other feeding-stuffs, on a pound-for-pound basis, and in some cases this has led to digestive disturbances. On a starch equivalent basis feeding-stuffs in Table XXXIII are equal to 1 lb. of oats, and for comparative purposes the P.E. is also given.

TABLE XXXIII
COMPARATIVE VALUES OF SUBSTITUTES FOR OATS

Lb. of Food	Food	P.E. (lb.)	Cost of Food to provide Equivalent S.E. to that of 1 ton of Oats
			£
1·00	Oats	0·08	10·50
0·83	Wheat	0·08	7·88
0·83	Barley	0·06	7·88
0·83	Rye	0·08	6·64
0·77	Maize	0·06	5·39
0·71	Flaked maize	0·07	6·39
0·98	Dried sugar-beet pulp	0·05	5·39
0·80	Linseed cake	0·20	8·40
0·90	Beans	0·18	8·55
1·00	Bran	0·12	8·00
3·21	Potatoes	0·03	4·81
6·76	Carrots	0·04	6·76
9·44	Mangolds	0·04	5·65

N.B.—The same prices are taken per ton as those used in Tables I and II, pp. 191 and 193, for 1937–8, except that for rye £8, for potatoes £1 10s. and for carrots £1 per ton have been charged.

It is not suggested that it is worth while replacing the whole of the oat ration, but it may be seen from the last column of Table XXXIII where, for each food, the cost of S.E. equivalent to that found in 1 ton of oats is given, that economies may be made if some other foods are used to replace part of the oats. It is usual to feed about one-half or two-thirds of the ration as oats and then one of several of the foods in the above list may be used to complete the ration. Usually rye or wheat should not exceed one-quarter of the concen-

trates fed because they are likely to cause indigestion. If sugar-beet pulp is fed (and many horse keepers refuse to feed it at all), it should be soaked before feeding, but that is not absolutely essential. Linseed cake is usually only given to horses that are unthrifty, and when it is necessary to gain a little condition, or to mares towards the end of pregnancy; in such cases only 2 lb. of linseed cake are given daily. Beans are considered to be excellent for horses doing hard work, when it is quite common practice to feed extra concentrates—sometimes all of the extra concentrates are given in the form of beans; this may be at the rate of 4 lb. per head daily. Bran is frequently given to horses in their ordinary concentrated mixtures but it must not be used to replace an equal weight of oats. Quite commonly equal quantities of maize and bran will replace equal quantities of oats satisfactorily; bran has a special use as a mash for working horses and this will be discussed later. Up to 20 lb. of roots may be given to horses daily, and in the Fens, where big yields of roots are often obtained per acre, it is usual to feed mangolds to horses after the roots have been harvested and matured.

For the ordinary working horses on a farm the only other food that merits consideration is salt. Rock salt may be placed before horses for them to take at will. Other minerals are not usually required by the ordinary farm horses, but brood mares and young stock may sometimes require small quantities of calcium, phosphorus and iodine. The easiest way of supplying these substances is to give salt licks that contain the necessary minerals.

Since many readers may wish to know of actual rations that have been given to working horses with satisfactory results Table XXXIV may be cited:

(N.B.—In Table XXXIV parts have been quoted by weight and have been fed in winter at rates of 14 lb. per head per day.)

TABLE XXXIV

MIXTURES FOR WORKING HORSES SHOWING A HIGH PROPORTION OF OATS IN THE RATION

A		B	
4 parts	Crushed oats.	4 parts	Crushed oats.
1 part	Cracked maize.	1 part	Crushed rye.
1 ,,	Bran.	1 ,,	Bran.

C		D	
4 parts	Crushed oats.	5 parts	Crushed oats.
2 ,,	Bran.	2 ,,	Bran.
1 part	Crushed wheat.	1 part	Crushed wheat.

E

7 parts Crushed oats.
3 ,, Bran.

F

7 parts Crushed oats.
6 ,, Flaked maize.
1 part Cracked beans.

G

3 parts Crushed oats.
1 part Flaked maize.

TABLE XXXV

MIXTURES FOR WORKING HORSES SHOWING A LOW PROPORTION OF OATS IN THE RATION

A

2 parts Crushed oats.
1 part Cracked maize.
1 ,, Bran.

B

2 parts Crushed oats.
1 part Crushed wheat.
1 ,, Crushed rye or barley.
1 ,, Cracked maize.
1 ,, Bran.
½ ,, Cracked beans.

C

3 parts Crushed oats.
5 ,, Cracked maize.
4 ,, Bran.

D

1 part Crushed oats.
1 ,, Flaked maize.
3 parts Decorticated ground-nut cake.

E

2 parts Crushed oats.
1 part Flaked maize.
1 ,, Bran.
1 ,, Crushed wheat, rye or barley.
½ ,, Cracked beans.

TABLE XXXVI

MIXTURES FOR WORKING HORSES SHOWING OATS OMITTED FROM THE RATION

A

2½ parts Cracked maize.
1 part Crushed rye or barley.
1 ,, Crushed wheat.
2 parts Bran.
½ part Cracked beans.

B

2 parts Cracked maize.
½ part Crushed rye or barley.
½ ,, Crushed wheat.
2 parts Bran.
½ part Cracked beans.

No mention has been made, so far, of the special value of bran for working horses. It is well known that on many farms, horses are liable to be very stiff and may have swollen legs from standing without any exercise in a stable over a week-end. During such periods the quantity of concentrates fed daily should be reduced; this will minimize the trouble that may arise from this source. Another possibility, and one that is very commonly adopted, is to feed a bran mash to horses after they have finished work on Saturdays. If 4 lb. be allowed for each horse and water, preferably warm, is added and allowed to stand for half an hour before feeding, the mash will tend to keep horses well at week-ends. Fed in this way, bran is laxative and tends to clear out the whole digestive tract. Bran mash is also a valuable food for any horse that is ill and when it will not eat any other foods; for such purposes it has medicinal value, and prices higher than those usually given for the mere nutrients contained in bran, may be worth while.

During the summer-time horses may be housed, if there is little or no grassland available, or they may go to pasture when not at work. Usually, if housed, no change is made in the ration in comparison to that being fed during the winter except that as green-soiling crops, such as lucerne, oats and tares and various seeds leys, become available they may be given. If horses go out to grass during the summer it is usual to feed no roughages other than chaff except in periods of drought, and then the green-soiling crops, mentioned above, may be given. As has already been mentioned, the quantity of concentrates fed daily will fall during the summer period and may easily reach the low level of 7 lb. per head daily. As grass deteriorates, the weather turns colder and the grass may be covered with frost; housing of working horses is then usually considered necessary. In general, horses are housed from 1st October to about the 1st May, but there are variable differences between districts in this respect.

The next phase in horse-feeding that should be considered is the feeding of brood mares. Taking the country as a whole, the majority of brood mares of the many breeds work throughout pregnancy; the principal exceptions to this rule will be found in studs where pedigree stock are being produced. There expense is not being considered, and the aim is to obtain a foal which will be well developed for age; to obtain the maximum size in the foal the mare cannot expend energy and nutrients in working. Against this viewpoint it must be emphasized that exercise is essential for a brood mare and the cheapest way, provided it is not given in excess, of exercising a mare is to work her up to the time of foaling. Here it is proposed to

discuss the feeding of a mare that is actually working during the later stages of pregnancy. It must not be forgotten, however, that after about the sixth month of pregnancy mares must be worked with care and only "in chains." Long fasting should be avoided and if possible pregnant mares should return to the stable at midday for food and for water, the latter being particularly important. A brood mare should not be permitted to become excessively fat for that may lead to difficulties at foaling. On the other hand, a mare, especially when working, may become so thin that she has not sufficient reserves to help her at foaling time and for proper milk production afterwards. A skilful horse keeper will keep his horse just in the right condition; this usually involves giving small quantities of extra concentrates, about 2 to 4 lb. more than is required merely for work. Quite commonly the ordinary working horse ration is fed in the larger quantity daily, but better results may be achieved by feeding 2 lb. of linseed cake, or of beans, daily, the linseed cake being especially beneficial in the case of unthrifty mares or with a filly in foal for the first time.

As foaling approaches no further change in feeding is made except that the ration must be laxative; roots or green foods may be given to provide natural laxative food or bran mash may be resorted to. The actual place of foaling depends on individual taste; many horse-breeders foal their mares in boxes whilst others find they have less losses by foaling mares out of doors or in paddocks. In the latter case grass will, of course, be the laxative diet, provided foaling does not take place too early in the year.

An orphan foal may arise from time to time and it is necessary to discuss the feeding of such an unfortunate animal. Cows' milk is usually the only other milk available, but that is invariably richer in butter-fat than mares' milk and it is less sweet and contains less minerals, especially calcium, than are found in mares' milk. A suitable substitute may be made by taking a pint measure and by adding 2 teaspoonfuls of sugar, 4 tablespoonfuls of lime water and cows' milk to fill the measure. At first the foal should be fed ½ pint of the mixture each hour during the day, and after a few days the intervals between feeding may be lengthened and the quantity given may be increased to 2 gal. per day in four feeds. By the time the foal is six weeks old skimmed milk may be substituted gradually for whole milk and the feeds may be reduced to three daily. It is possible to wean the foal when it is three months of age, by which time it will be eating concentrated foods (as described later) quite freely, in addition to good-quality grass.

After foaling very little food need be given to the mare for the first day and an attempt should be made to give foods that are naturally laxative. The actual feeding of concentrates will depend largely on the system of rearing that is adopted; the possible methods are: (*a*) for the mare to do no work for the first half of the suckling period and thereafter to suckle and to work as required, (*b*) for the mare to suckle for three months only and for the foal to be weaned at an early age when the mare is wanted for work, and (*c*) to work the mare more or less throughout the whole of the suckling period. If breeding is the main consideration, system (*a*) will be adopted and then large well-grown foals will be produced without any undue strain upon the mares; where the mares must work as much as possible they cannot work hard and also produce large quantities of milk, with the result that the foals suffer as also may the mares. Unthriftiness in foals when mares are working is not entirely because they receive less milk, but also because of the mental upset that may be occasioned when the foal is separated from the mare whilst the latter is working. It is also well known that mares fret when away from their foals and this results in their milk being of poor quality, and also in the mares losing condition. In some countries, where there is less traffic on the roads than in this country, mares are worked and the foals run beside them; this obviates the mental distress experienced when foals are separated from their mares.

Taking the first case, where a foal suckles its dam for five months and the latter does no work, the feeding is usually very simple; the mare and foal are turned out to grass as soon as possible after foaling (10 to 20 days), or if she has foaled at grass they run out at grass, with grass as their sole food. Before turning out to grass the concentrates fed will be bran and oats, fed in small quantities just after foaling, and reaching 6 to 8 lb. before they are turned outside. Good hay should be given but the daily ration must be kept low till the mare has recovered fully from foaling. Usually mares milk freely on grass and no additional food is necessary till weaning time. If mares are worked whilst suckling they are fed according to the amount of work they are doing, their condition, and the amount of grass available. Actual mixtures will be the same as those used for working horses, but the quantities fed will be 4 lb. per day more than given to the non-breeding working horses.

As the time of weaning approaches it is necessary to teach the foal to eat concentrates; the best teacher is its own mother. For two or three weeks before weaning a trough should be placed in the field in which the mares and foals are kept. (It is most satisfactory

to have at least two mares and their foals in a field because the foals settle better after weaning if at least two foals are kept together.) Various mixtures of concentrates may be used, but any of those in Table XXXVII have been given with success to brood mares and foals:

TABLE XXXVII
MIXTURES FOR MARES AND FOALS

A	B
25% Crushed oats.	30% Crushed oats.
25% Bran.	25% Bran.
25% Linseed cake.	20% Linseed cake.
18% Flaked maize.	20% Flaked maize.
7% Fish meal.	5% Fish meal.
C	**D**
25% Crushed oats.	50% Crushed oats.
25% Flaked maize.	22% Bran.
25% Bran.	22% Linseed cake.
25% Linseed cake.	6% Fish meal.
E	**F**
45% Crushed oats.	67% Crushed oats.
15% Bran.	33% Linseed cake.
15% Linseed cake.	
20% Cracked beans.	
5% Fish meal.	

Any of the rations in Table XXXVII may be fed with absolute safety at quantities of 3 to 6 lb. per day after weaning till the end of the foal's first winter. When the mare and foal are being fed together the mare is not only teaching the foal to eat from a trough, but she is also eating concentrates that are essential to get her into a fit condition for working. The actual ration will be small in the first instance, but after a week or ten days of feeding may reach a stone a day. At weaning the mares should be removed right away out of earshot of the foal, for working, and the foals should be housed for a few days till they have forgotten their dams; it is at such times that several foals together settle far better than if only one foal is being kept in solitary confinement.

Whilst the foals are housed at weaning-time the opportunity should not be missed of treating them for red worms. This is an ideal occasion for this treatment, for if well done the foals will thrive well during the first winter, even if they are fed cheaply. For the

de-worming process the foals need to be housed for three or four days in all and then taken out to grass again. In many districts in the country foals can spend this first winter out at pasture and suffer no harm, provided they receive concentrates in the quantities mentioned above; if bad weather is experienced a small quantity of hay should be given long, or hay chaff may be added to the concentrates; this is most necessary when the ground is covered with snow and grass cannot be obtained. Alternatively, in arable districts, e.g. the Fens, when horse-rearing is practiced it is quite common to put foals in a straw yard for their first winter; there they will receive concentrates as described above for outdoor rearing, with hay and straw as the maintenance part of the ration. It is difficult to give actual quantities of hay required, but 7 to 10 lb. should be allowed per day as a rough guide to requirements.

After the end of the winter the foals, then yearlings, may either remain out at grass or be turned out at grass in early spring. As soon as there is any appreciable quantity of grass available concentrates may be omitted, and for its second summer the yearling will normally receive nothing except grass.

During its second winter the yearling will usually receive some concentrates, and for simplicity it may be given the same mixture as that during its first winter; on the other hand, to reduce costs a cheaper mixture may be used such as, 2 parts by weight Crushed oats, and 1 part by weight of Bran, or equal parts of Crushed oats, Bran and Cracked beans may be used. The actual quantities of concentrates fed to yearlings will be about 3 lb. per head per day. As in the previous year, hay will be fed when snow is on the ground if the yearlings are outside; if they are housed in yards all winter, hay or straw may be fed daily.

Working horses are usually broken to work when they are 2 to 2½ years old; thus a few two-year-olds will be broken in during their third autumn. If breaking is to take place at 2½ years the third summer is usually spent at grass; no food other than the grass will be given till the time for breaking approaches. When young horses are to be broken-in to work it is essential to feed them concentrates to get them fit for work; for this purpose the same mixture as that given to the ordinary working horses may be used, and the quantity will be about 7 lb. per head daily. The quantity must, of course, depend on the condition of the horse and the amount of work being done. If the horse should be difficult to handle it may be a sound policy to reduce the quantity of concentrates fed till breaking is nearly complete.

All of the above feeding is based on ordinary commercial stock and normal rations have been given; in pedigree studs, however, grooms may be feeding very different rations from those mentioned above. They would certainly feed their young horses vast quantities of hay during the winter even if they were out on good-quality pastures. It is not possible to give the many ideas that are prevalent amongst grooms.

The feeding of heavy horses will not be complete unless some mention is made concerning the feeding of breeding stallions. In this connection it must be emphasized that there are no principles upon which to base rations, only the experience of those who have successfully kept stallions for breeding purposes. Some breeders work stallions during the winter-time and feed them as ordinary working horses; without a doubt this treatment keeps the horses fit and does not impair (and may easily improve) their breeding abilities. If a stallion has no long distances to walk during the breeding season, then field work may easily be an advantage in keeping him fit. In this country where stallions usually travel this in itself affords ample exercise, then no necessity arises for field work.

The actual rations given to stallions for a short time before, and during, the breeding season are very varied. Some breeders feed oats as the sole concentrated food and as much leguminous hay as the stallion will eat; others feed mixed concentrates similar to those given to working horses and any good-quality hay that may be available. One breeder, known to the authors, feeds nothing but beans for a travelling stallion (and with good results) but many breeders would look aghast at such a ration. To ensure high fertility some grooms give ½ lb. of fish meal to stallions throughout the winter in addition to any other concentrates that may be fed, whilst others, to produce the same result, feed sprouted oats; scientifically, both foods should produce good results. Without any doubt many different rations may be used, and for safety a good proportion of oats should be used together with good-quality hay that contains plenty of the leguminous plants. Quantities given must depend on the size of the stallion and on his condition; he must not be too fat nor must he be lean. In general, a breeding stallion requires as much food as a working horse of the same size at full or at hard work.

This chapter would not be complete if no mention were made of the feeding of light horses and possibly of race-horses. Here, without a doubt, one passes from the sphere of science into the realms of art, but only sound feeding will be given. It is interesting to

observe, however, that with the light horse, hacks, hunters and race-horses, trainers and farmers also pin their faith to oats as the main-stay in feeding horses. So keen are these feeders that they give fantastic prices to obtain the best quality of oats that are produced, because they are convinced there is no food like oats for horses. Both hunters and race-horses in training receive oats as the chief concentrated food, in quantities even larger than those given to the ordinary heavy horses in full work on the farm. This really means feeding at a higher rate than for the heavy horses because the hunters are so much lighter than heavy farm-horses. These race-horses and hunters, being smaller, have smaller capacities than the heavy horses; thus the quantity of hay fed is much lower than for heavy horses, but care is exercised to see that only first-quality is fed.

When hunters are required for the season they are usually brought in from pasture (where they have been turned to save expense [in spring] at the end of the previous hunting season) and fed on a ration of corn and hay; this reduces the development of belly, a temporary condition arising from consuming large quantities of grass, and it develops a certain amount of stamina which is necessary for staying power when hunting. When brought in for feeding, exercise is essential, and the hunters must be exercised daily if they are to be made fit for the season.

No mention has been made of the light horses used for traps and odd carting on farms; these can be fed in precisely the same way as the heavy horses except that the quantities of foods given will be lower, being in proportion to the size of the horse and according to the work being done. It must be explained, however, that daily work on the road delivering milk for, say, seven days a week, is very arduous, and ponies may require relatively large rations of corn if they are to remain fit for any appreciable periods. They may frequently eat up to 10 lb. of corn if working hard.

Finally, it must be pointed out that for horses of all classes and of all ages oats form the basis of the ration and "hard" hay forms the basis of the hay ration, but there are many deviations that can be made in the feeding of horses; many horse keepers and grooms prefer, however, to use the old tried rations and are loath to use the newer ones.

XV

FEEDING POULTRY

Definitions.

THE term "poultry" comprises barndoor or domestic fowls, ducks, turkeys and guinea fowl. In this book, the term "fowl" will be used exclusively as a generic term to cover all classes of domestic or barndoor fowls. Young fowls up to the end of the brooder period will be referred to as "chicks," thereafter up to the age of maturity as "chickens" or "growers." Male chicks will be referred to as "cockerel chicks," female chicks as "pullet chicks." Mature females in their first year will be called "pullets," thereafter "hens." Similarly mature males in their first year will be called "cockerels," thereafter "cocks." Young ducks will be called "ducklings," young geese "goslings." Mature male ducks will be called "drakes," mature male geese "ganders" and mature male turkeys "toms."

Systems of Management.

Unlike most other livestock, poultry are kept under such widely varying and diverse systems of management, and these systems of management so vitally affect their nutritional needs that it becomes essential to consider the nutritional needs of poultry with strict regard to the system of management adopted. Under the most natural form of management, the extensive system, incubation and rearing is carried out by the broody hen, the growers are reared in Sussex arks or portable houses on free range, and the laying and breeding stock are kept on pasture or arable in portable houses. Under such a system, comparatively simple food mixtures suffice, since the birds can supplement the deficiencies of such diets by the materials they pick up during foraging. Moreover, in the search for such materials, the birds get plenty of fresh air, sunshine, and exercise, all of which materially contribute to keep them fit and healthy.

At the other extreme of management, the intensive system, the eggs are artificially incubated, the chicks are brooded in battery cages, the growers are reared indoors or with limited access to grass-

land, and the laying stock are kept in confinement or in hen battery cages. In between these extremes are systems of management which are partly intensive and partly extensive in character in varying degrees. The intensive system is so artificial in character and divorced from Nature that special care in management and complicated food mixtures are necessary to maintain the bird in health or egg production. The lack of fresh air makes it incumbent upon the poultry keepers to pay special attention to the ventilation of the poultry houses and other equipment in order to ensure that the birds get an adequate supply of air and to maintain the temperature of the house and the humidity of the air at an optimum level. In brooder equipment extra care is also needed to ensure that the temperature is kept at a suitable level and to prevent the floor from sweating. In brooder houses with adequate floor space the chicks may obtain sufficient exercise to keep them healthy in spite of the restricted accommodation, but as the chicks reach the growers' stage, the lack of opportunity for exercise becomes a serious drawback and limits the extent to which birds may be successfully reared under this system.

The lack of sunshine is also serious. In certain types of intensive house this handicap is overcome by the proper siting of the house and the provision of open wire fronts to the houses, or by providing an outdoor wire floored run, euphemistically referred to in the United States as a "sun parlour." In the case of the battery brooder and the hen battery cage this handicap is overcome by giving cod-liver oil which contains Vitamin D and so acts as a sunshine substitute.

Systems of Feeding.

General Considerations.

Under natural conditions, fowls live largely on the leaves and tender shoots of grasses and other green plants, worms, caterpillars, insects, etc., and the seeds of grasses and cereals and other food plants. Under domestication the food consists largely of cereal grains and cereal by-products supplemented by green foods such as cabbage, thousand head kale, etc., and roots such as turnips, mangolds, swedes, carrots, etc. Such foods are rich in starch or sugar, but poor in protein or flesh formers; consequently protein-rich foods such as meat meal, dried or liquid milk, earth nut meal, and fish meal are employed in order to provide for this protein deficiency. Under intensive systems, such diets, although properly balanced for carbo-

hydrate, fat, and protein may be deficient in vitamins and minerals; to compensate for this deficiency foods such as milk, whey, dried yeast, alfalfa or lucerne meal, grass meal, and cod liver oil are included in the diet, and mineral mixtures in which common salt, bone meal or steamed bone flour, ground chalk or limestone or oyster shell, form the principal ingredients, with potassium iodide, and manganese, iron and copper salts as minor ingredients, are often added.

Apart from the question of including in the diet all the ingredients essential for adequate growth, maintenance of health, successful egg production, and the production of hatchable eggs, the maintenance of an adequate food intake is of primary importance. Even casual observation will show that fowls vary in their likes or dislikes for certain foods. Some foods are readily eaten in their natural state, others are rejected. Some are readily consumed in the form of a powder or mash, others fed in this state are refused. Similarly, certain foods if presented in a dry condition will be refused whereas they are readily eaten if given in a moist condition. The factors of importance which determine whether a food will be eaten by fowls are attractiveness of appearance, mechanical condition, and method of presentation. Fowls possess a well developed colour and form sense, and are attracted by foods which are light in shade of colour or which readily reflect light. On the other hand they possess a poor sense of taste and smell, the flavour and odour of food which is so important to humans is consequently of secondary importance so far as fowls are concerned. The sense of sight and touch are extremely well developed. It has been shown that fowls pick up foods from hard surfaces, such as metal, concrete and stone less readily than from earth or wood, consequently the nature of the materials from which the food hoppers are constructed may become important factors in adequate food consumption. In addition, foods which are dusty in character, or which are composed of sharp angular particles are disliked, and foods which swell considerably on wetting are also unpalatable to fowls if fed in a dry state. Foods of this latter class, or foods which are dusty in character, may generally be rendered palatable by soaking prior to feeding.

It is on account of the operation of these palatability factors that we find among poultry keepers several different methods of feeding in common use. They are

1. All grain feeding.
2. Mash and grain feeding, with the mash fed either wet or dry.

3. All mash feeding, with the mash generally fed dry.
4. Pellet feeding.

The method of feeding usually adopted is grain and mash. The grain is, if of a suitable size, fed whole to growers and layers, for chicks it is broken by cracking, cutting or kibbling. Oats are usually clipped before feeding, and barley is screened to remove the awns. The mash, if composed of suitable ingredients, can be fed in a dry state in hoppers, otherwise it must be fed as a wet mash to ensure palatability. When wet mash feeding is adopted it is customary to feed the grain morning and evening, and the wet mash mid-day. In making wet mash, care is taken to ensure that the mash is of the right consistency, that is, sufficient water is added to produce a dry, crumbly mash which adheres together when squeezed but readily breaks apart when thrown to the ground. Much discussion has taken place among poultry keepers as to the relative merits of wet and dry mash, some holding the view that dry mash feeding is better, others that wet mash feeding is the sounder practice. This difference of opinion is largely due to the operation of the factors making for palatability: if the mash is made from ingredients palatable in a dry state and the conditions of management are hygienic as good results will be obtained from such a mash whether it be fed in a dry or wet state. On the other hand, if the ingredients of the mash are of a dusty character or swell on wetting, bad results will follow if the mash is fed dry whereas excellent results may be obtained if the mash is fed wet. The advantages of dry mash feeding are the saving of labour that results and the convenience of giving the birds several days supply of food at one time by placing it in suitably constructed food hoppers. The disadvantages are the limited choice of foods suitable for feeding in a dry state, loss of food that results from scattering round the food trough, and the action of high winds if the troughs are in the open, and the further loss of food through the depredations of rats, sparrows, and other vermin. In addition, the danger of the spread of a disease such as coccidiosis is increased, since it has been shown that the food hopper and the water trough are two important agents in the spread of this disease. Furthermore, dry mash feeding encourages lazy poultry farming and the flock may not come under the observation of the poultry keeper as often as is desired, thus again encouraging possible spread of disease. The main disadvantage of the wet mash method is the increased cost of labour; the advocates of this system claim however that the extra cost of labour is more than compensated for by the saving in food costs. The advantages of the

wet mash system are the easier control of the food supply, the regularity of feeding hours (thus encouraging foraging and active exercise during the non-feeding periods), avoidance of wastage due to rats, sparrows, and other vermin, a wider choice of food ingredients, more regular observation of the flock, and the absence of the possibility of contamination of the food by the bird's droppings, with its consequent danger of spread of disease. It would thus appear that, on the whole, the advantages are in favour of the wet mash system. The advantages claimed for the wet mash system are also shared by pelleted mashes; in the latter case it is, however, essential that the feeding be controlled, as otherwise there exists a danger of overfeeding the birds.

The Feeding of Chicks.

Under the natural system of rearing, when only small lots of chicks are reared, as for instance by cottagers, more care and attention can be given to feeding than under commercial conditions of rearing. Under such circumstances, the chicks will be fed 5 times a day at regular intervals for the first 10 days, dropping to 4 times a day up to 8 weeks, and thereafter to 3 times a day. The first meal will be given when the chicks are 36 to 48 hours old, and will consist of small broken grains such as maize grits mixed with chick grit and fed on a flat board or stiff paper. The chicks will have been given already water to drink. As soon as the chicks have accustomed themselves to food, the food mixtures will be given in shallow wooden troughs. The following systems of feeding have been commonly practised.

1. During the first two or three days hard-boiled eggs, chopped fine, shell and all, are alternated with stale bread crumbs moistened with sweet milk. As they get older vary the diet with oatmeal, maize meal, or barley meal, moistened with water or milk, and with broken oats, barley, or wheat as a dry grain feed, with occasional small quantities of hemp or buckwheat.

2. During the first two or three days the food consists of oatmeal moistened with water and mixed with hard boiled eggs. Afterwards the food consists of a wet mash made up of two-thirds by weight of oatmeal, and one-third of weatings or fine bran, with 1 lb. of bone meal mixed in with every 14 lb. of mash. Occasional feeds of broken grains are also given.

3. During the first few days the food consists of an egg beaten in two teaspoonfuls of milk and dried off with breadcrumbs, followed

later by groats and small seed, with some animal food such as finely chopped meat when insects, worms, etc., are unobtainable. An occasional feed of finely chopped lettuce or onion tops should also be given.

Feeding Chicks under Commercial Conditions.

The systems of feeding given above are obviously impracticable under commercial conditions where large numbers of chicks are being reared in brooder houses or battery brooders. Under such conditions, it is best to feed a dry mash and to give the chicks free access to it all the time, and to feed the grain mixture three or four times a day. In the case of battery brooder reared chicks, dry mash only is used as a general rule. In small commercial units, using brooder houses with outdoor grass runs, it is possible to adopt a wet mash and grain system, and it is claimed that better results are obtained this way than by the dry mash and grain systems adopted in larger units. In both cases the control of the growth of the chicks is obtained by varying the amount of the grain feed given daily, retardation or slowing of growth being obtained by increasing the amount of grain feed given. In the case of chicks reared on the all mash system, retardation of growth is obtained by reducing the protein content of the mash. In allocating the proportions of grain to mash, the amount of grain fed should be gradually increased until it is equal to the mash consumption at 12 weeks, increasing the grain to mash after this age so that at 14 to 16 weeks the grain fed represents two-thirds of the total ration. From 16 weeks on the grain fed will be varied according to the condition of development of the birds, increasing the amount if the birds are too forward in development, decreasing it if the birds are backward. In the first two or three weeks, 3 grain feeds a day will be given, later on the number grain feeds can be reduced to two a day, a light grain feed being given in the morning, and a heavy grain feed in the evening so as to ensure that the birds go to roost with full crops. If the grain is fed in hoppers, it will be necessary to ensure that no more grain is put into the hoppers than can be cleared by the birds before they go to roost. This can only be done by inspection of the hoppers after the birds have retired to roost, since inspection of the hopper when the birds are released from the houses in the morning may give false information. In a case in point, where the poultry keeper complained that the dry mash was unpalatable since the birds did not begin to eat it until about 11 o'clock in the morning, it was found that excess grain was put in the food hoppers in the afternoon. The result was

that the birds cleared up the excess grain on rising and naturally did not begin to eat the mash until late in the morning.

Suitable Grain Mixtures for use in a Grain and Mash System.

Day-old chicks to 6 *weeks.*
3 parts Cracked or cut wheat.
3 parts Fine maize grits.
1½ parts Cut groats or pinhead oatmeal.

6 *Weeks to* 12 *weeks.*
3 parts Cut wheat.
2 parts Medium grade cracked maize.

12 *Weeks to Maturity.*
3 parts Wheat.
2 parts Kibbled maize.
1 part Clipped plump oats.
or
1 part Kibbled maize.
1 part Wheat.

At Maturity.

During Winter Months.	*During Summer months.*
4 parts Kibbled maize.	3 parts Wheat.
2 parts Wheat.	2 parts Kibbled maize.
or	1 part Plump clipped oats.
4 parts Kibbled maize.	*or*
1 part Wheat or rye.	3 parts Wheat.
1 part Barley.	1 part Clipped oats.
	1 part Barley or rye.

Quantities to Feed.
As explained above, the actual quantities of grain to feed must depend on the individual judgment of the feeder; but as a rough working guide the following amounts of grain per day should suffice for 100 birds:

Age in weeks.	*lb. of grain daily.*
1	⅛
2	½
3	1¼

Age in weeks.	*lb. of grain daily.*
4	2
5	2½
6	3
7	3¾
8	4½
9	5
10	5½
11	5¾
12	6¼
13	7½
14	8¾
15	10
16	12
Adults, light breeds	10
heavy breeds	12

Mash Mixtures for use in a Grain and Mash System.

1. *For Birds kept Semi-intensively or on Free Range.*

	Day-old to 6 weeks	*10 weeks to maturity*
Bran	20	20
Weatings	40	40
Yellow maize meal	26	30
Sussex ground oats	14	10
Fish meal or meat meal ..	7	7
Dried skim milk or dried whey ..	7	—
Common salt	½	½
Cod liver oil	1 pint	—

The change over from the first mash to the second is achieved gradually by mixing the two mashes. In the 7th week a mixture of the two mashes in the ratio of 3 to 1 is given, in the 8th week in the ratio of 1 to 1, in the 9th week in the ratio of 1 to 3, so that in the tenth week the birds are changed over to the second mash. Hoppers containing insoluble grit consisting of flint grit or suitably graded gravel, and supplies of oyster shell or limestone chips should be supplied so that the birds can help themselves at will. Fresh

water should also be available at all times. The mashes can be fed either as wet or dry mash as desired.

2. *For Birds kept Intensively or in Battery Brooders.*

Owing to the necessity of including all the bird's requirements, a mash used for intensive or battery brooder conditions has to be more complicated than under semi-intensive or free range conditions. In addition, for the first 8 weeks no grain is given, and the mineral supplements needed are included in the mash. After 8 weeks, the rations can continue as all mash or as grain and mash. The grain mixtures already given are suitable for use if a grain and mash system is used.

	Day-old to 8 weeks	*12 weeks to maturity*	
	all mash	all mash	grain and mash
Bran	17	10	18
Yellow maize meal ..	33	40	28
Weatings	23	21	23
Sussex ground oats ..	7	14	10
Dried skim milk ..	7	—	—
Fish meal or meat meal	7	4	8
Dried yeast	3¼	2	3
Limestone flour or ground chalk or whiting	2¼	—	—
Sterilized steamed bone flour	—	1½	2
Common salt	½	½	½
Alfalfa or lucerne meal	—	7	7½
Cod liver oil	½ pint	½ pint	1 pint

From 8 weeks onwards the birds are allowed free access to oyster shell and insoluble grit, and the change over from the first mash to the second is achieved gradually by the method already indicated.

Feeding for Egg Production.

As the growing pullets reach the egg-laying stage the combs begin to swell and redden up. The birds, which up to this time have been housed in Sussex arks in the open fields or on the stubbles are now brought into their laying quarters and put on layers' rations. Several different systems of housing the layers are in common use,

and owing to the effect of the system of housing on the food requirements it is desirable to discuss the feeding of layers in relation to the type of management adopted.

1. *For Cottagers, and 'Backyarders.'* *

The cottager or 'backyarder' usually keeps a few hens in a small shed with a wire run attached at the bottom of the garden, for the purpose of supplying the household with eggs for home consumption, and to utilise household waste that would otherwise be useless. The household scraps, consisting of potato peelings, stale bread, cabbage leaves, meat scraps, and the waste from the table, are thoroughly cooked in a minimum of water, and dried off with bran or weatings. One handful per ten birds (measured palm downwards) of fish meal or meat and bone meal is rubbed into the cooked scraps and the whole fed to the birds in a wooden trough, preferably in a warm state during cold weather. This wet mash will usually be given as an afternoon feed. For the morning feed, a ration of grain will be given, allowing 6 handfuls of grain for every ten birds. If available, waste green vegetables from the garden can be occasionally given. The grain mixture used can consist of any of the grain mixtures advocated for use elsewhere in this book. Oyster shell or limestone grit, and insoluble grit such as flint grit or suitably graded gravel should also be always available, together with adequate supplies of fresh water to drink.

2. *For Semi-intensive Systems.*

In the semi-intensive system the layers are kept in flocks in permanent wooden houses with grass runs attached. Each house is supplied with two grass runs, so that one may be rested while the other is in use. The birds are thus enabled to get a limited amount of food from the run and opportunities for adequate exercise, fresh air and sunshine. For this system of management, the grain and mash method of feeding is most suitable. If the mash is dry fed, the dry mash hoppers are kept open all day, and the grain ration is fed in the late afternoon, either in hoppers or preferably scattered in the grass run. The usual allowance of grain is 1½ oz. per head per day for light breeds and 2 oz. for heavies. If the mash is fed as a wet mash, the usual custom is to feed a small allowance of grain first thing in the morning, as much wet mash midday as the birds will clear up in 20 minutes to half hour, and the rest of the grain in the late afternoon, or evening. The birds should have free access to hoppers containing oyster shell or limestone chips and insoluble

* For poultry keeping in wartime by Domestic Poultry Keepers see p. 333 in Chapter XVI.

grit. Ample supplies of fresh water to drink should also be available.

Mash Mixtures (all parts by weight).

	1.	2.	3.	4.
Bran	20	20	20	22½
Weatings	40	20	20	22½
Yellow maize meal ..	20	20	20	22½
Ground oats	10	10	10	22½
Barley meal	—	10	—	—
Ground wheat	—	10	20	—
Fish meal or meat and bone meal	10	10	10	10

(To 100 lb. of every mash add ½ lb. salt and thoroughly mix.)

Any of the above mash mixtures are suitable whether fed wet or dry.

Cabbage or kale should be fed in addition during the winter months. For grain food, any of the mixtures given on page 303 will be suitable.

A more economical method of feeding can be achieved by leaving out the fish meal or meat and bone meal and so starting the layers on a cereal mash only. When the birds have settled down into production, an egg production mash constructed as indicated in the chapter on feeding standards is given as a wet mash midday. If the expected increase in egg production follows, the quantity of egg production mash is increased until the stage is reached where no further response from the birds is obtained, or until the cost of the added mash exceeds the value of the extra eggs produced. By this means the feeding of the birds is maintained at a truly economic level, the expensive protein foods only being used insofar as they yield an economic return. Under the normal method of feeding, where the protein supplements are included in the general mash, the amount of protein added has to be the amount calculated to be necessary for the highest level of expected production. Consequently there is a waste of protein food while the flock is reaching the anticipated level or if the flock does not reach the expected level of production. In addition, birds with low production receive as much protein as those with high production, whereas if the protein is fed as an egg production mash, the high producers who are the more eager feeders have the opportunity of getting the extra protein they need.

3. *For Intensive Systems.* (Birds kept in laying houses with no access to grass or range.)

Birds kept on the intensive system have no opportunity of getting green food, consequently green food such as kale or cabbage must be supplied in addition to the mash and grain, or alternatively lucerne or alfalfa meal must be supplied in the mash. Otherwise, the eggs laid by the birds will have pale yolks, and since pale yolked eggs are regarded with disfavour by the average consumer, the market value of such eggs will be reduced. In addition, the birds will have less opportunities of exposure to sunshine or of acquiring vitamin-containing foods, consequently cod liver oil is included in the mash to make up for such deficiencies. With birds kept intensively, either an all mash system or a grain and mash system can be used, but in both cases the mash is fed in a dry condition.

Access to grit and limestone chips or oyster shell should always be provided, and ample supplies of fresh water placed conveniently near to the food hoppers. A dusting bath of clean sand or sawdust containing carbolic powder or some other form of powder disinfectant should also be available.

Mashes for use in Intensive Systems.

	All mash	Mash and grain system
Bran	10	20
Yellow maize meal ..	45	21
Weatings	24	30
Sussex ground oats ..	7	10
Alfalfa or lucerne meal ..	5	7
Fish meal	7½	10
Salt	½	½
Cod liver oil	1 pint	1½ pints

Grain (for use only in grain and mash system).

1½ oz. per head per day for light breeds and 2 oz. for heavy breeds of the following mixtures:

	Winter	Summer
Wheat	1	2
Kibbled maize	1	1
Clipped oats	1	1

4. *For Birds kept in Hen Battery Cages.*

It is more convenient to include the mineral requirements of battery cage birds in their food supply rather than give them separate access to it. Occasionally a little flint grit should be scattered over

the mash. An all mash method of feeding is also advocated, since if grain is fed, more scattering and wastage of the mash is likely to take place, since the birds rake through the mash with their beaks in search for grain. The one advantage of the hen battery cage system over others is the ease with which non-producers or inefficient producers can be detected and so removed from the flock.

Mash for use in Hen Battery.

	All mash
Bran	15
Yellow maize meal	35
Weatings	21
Sussex ground oats	10
Alfalfa or lucerne meal	7
Fish meal	7
Limestone flour, ground chalk or whiting	3½
Salt	½
Cod liver oil	1

5. *For Birds Folded on Grass.*

In this system, birds are housed in fold pens in flocks of 25 as a usual rule, and the pens are moved daily so that the birds are on fresh grass every day. By this method, the field is evenly grazed and manured. This system is suitable for the general farmer on farms of the down type in Southern and South Western England. Owing to the restricted nature of the fold pen and the close confinement, the only method of keeping the birds occupied is to feed a bulky mash. The water is given in a watering pail and the grain is fed once daily.

Mash for use in Fold Pens.

Bran	40
Ground oats	12
Weatings	24
Maize meal	15½
Fish meal	8
Salt	½

Grain.

Heavy breeds 2 oz. per head per day).

	Winter	Summer
Wheat	1	2
Kibbled maize	1	1
Clipped oats	1	1

6. *Fattening Mixtures.*

As soon as the sex of the chicks can be distinguished it is customary to separate the pullet chicks from the cockerel chicks and to fatten the cockerel chicks for table. In the case of battery brooded chicks, the cockerels may be kept on the chick mash and sold as "petit poussins" at 12 to 16 ounces live weight. In the case of the light breeds, this is the only method of marketing the cockerels that is likely to result in a profit. In the case of the heavy breeds, the birds may be kept on to the age of 17 to 18 weeks and marketed at a weight of 3½ to 4 lb. or more. In this case, the birds are transferred to Sussex arks in wired-in runs and fattened "on the run," or they may be picked up off the run, and given 14 days to 3 weeks fattening in fattening cages on wet mash. Such birds are said to be trough fed. Alternatively, the birds may be trough fed for 7 to 10 days and then finished off by means of a cramming machine, by which the birds are force-fed twice daily.

Birds Fattened "off the run." For birds fattened "off the run," the following dry mash mixture will be suitable, a grain feed being given in the late afternoon in addition.

Sussex ground oats	50 parts by weight
Dried yeast	3
Dried skim milk	10
Meat meal	5
Bran	9
Maize meal	20
Ground chalk	2
Cod liver oil	1

If fresh milk is available, the dried milk in the above mash can be omitted, and the birds given milk to drink instead of water.

Birds Trough Fed in Cages. Birds intended for trough feeding are kept on chick and growers' rations until the age of 14 weeks, when they are brought into fattening cages and given wet mash twice daily, as much mash being given as the birds will clear up in 20 minutes to half an hour. The mash is made up in a tub or barrel with sufficient water to make it into the consistency of a thick cream, and allowed to ferment for 12 to 24 hours before feeding. The usual mash consists of 13 parts by weight of Sussex ground oats and one part of dried milk, or of Sussex ground oats mixed with fresh milk or fresh buttermilk to reach the desired consistency. The following alternative mixtures can be used if Sussex ground oats are dear to buy.

		1.	2.	3.
Sussex ground oats	.. ..	32	32	22
Weatings or middlings	..	30	—	20
Barley meal	.. .. ..	—	30	25
Maize meal	.. .. ..	30	30	25
Dried skim milk	.. ..	8	8	8

Birds Trough Fed and Crammed. Birds trough fed and crammed can be trough fed on any of the above mixtures for 10 to 14 days, and then crammed on a cramming mixture for 7 to 10 days. The cramming mixture consists of any of the above mixtures to which mutton tallow or red palm oil is added in the proportion of 14 lb. of mash to 1 lb. of fat. The fat is melted and well rubbed into the mash, the water being added as before, and the whole allowed to ferment before placing in the cramming machine. The cramming mixture must be of a smooth creamy consistency free from lumps and air bubbles. The tube of the cramming machine is carefully pushed down the gullet of the bird until the end reaches the crop, when the mash is forced into the crop by means of the foot pedal until the crop is comfortably full. At each cramming the crop is felt to ensure that the crop is empty; if food from the previous cramming is still present, then a smaller quantity of mash should be given. At the time of cramming the condition of fattening is judged, and cramming is stopped when the bird has reached a suitable condition for killing.

7. *Breeders' Rations.*

Breeding stock laying eggs for hatching should receive special consideration, so that the eggs laid may contain all the factors necessary for the growth of the chick during incubation, and to ensure that the chick when hatched starts off in life with an adequate vitamin reserve for the first two or three weeks of its existence. The following mash and grain ration should prove adequate for this purpose.

Mash.

Maize meal	23½ parts by weight
Bran	15
Weatings or middlings ..	35
Sussex ground oats	10
Dried skim milk or dried whey	5
Fish meal or meat meal ..	3
Dried yeast	2¼
Alfalfa or lucerne meal ..	5
Cod liver oil	1½
Salt	½

Grain.

From 1½ to 2 oz. per day per head, according to condition, of the following mixture:

Wheat	3 parts by weight
Kibble maize	2
Clipped oats	2

THE FEEDING AND MANAGEMENT OF DUCKS

Ducks are essentially creatures needing free range in districts of lowlying pastures and running streams, and are consequently more suited to the general farm than the cottage garden or small holding. There are two distinct types of duck, the egg producing breeds such as the Khaki Campbell and the Runner duck, and the table meat breeds such as the Aylesbury and the Pekin. The breeding stock is selected during the autumn and mated up, one drake to 6 ducks in the egg laying breeds and one drake to 5 ducks in the table breeds.

The system of management is similar to fowls, but owing to their hardiness, much more primitive housing accommodation will serve. An open fronted shed or an outbuilding with the floor littered with clean straw will provide the necessary shelter at night, and if the birds are confined to the house from dusk to about 10 o'clock in the morning all the eggs will be laid in the house. The laying stock should get two ounces per head of maize in the morning, and three ounces per head of wet crumbly mash fed in a hopper at night. Fresh water in shallow trays should be placed near the mash hoppers, and trays containing sand. The depth of the water in the trough should be such that the ducks can easily clean their bills from any adhering sand. Suitable mashes for use by laying ducks are:

	1.	2.
Bran	20	10
Weatings or middlings	30	28
Maize meal	20	20
Fish meal	10	10
Green food	20	—
Soya-bean meal ..	—	5
Alfalfa or lucerne meal	—	7
Sussex ground oats ..	—	20

The green food can be made up of any growing green crop such as rye, maize, clover, grass, etc., cut up by machine into half inch lengths and mixed in with the wet mash.

Free access to oyster shell grit or limestone grit should be allowed.

Feeding and Management of Ducklings.

In small lots ducklings can be hatched and reared by broody hens, 10 duck eggs being enough for a sitting. The ducklings are kept with the broody hen for three weeks after hatching when they can be grouped into 50's and transferred to rearing quarters. In large lots, the duck eggs are hatched in incubators, the chief points being to see that the incubator temperature is not allowed to exceed 103° F. and to maintain adequate supplies of moisture. On hatching the ducklings are transferred to brooders, the temperature of which is held at 95° F. for the first week, 85° F. for the second, 75° F. for the third, and 65° F. for the fourth week. During spring and early summer, heat can often be dispensed with after the third week, beyond providing a hurricane lamp in the brooder house during very wet and windy weather.

Approximately 40 square feet of brooder space is required for 100 ducklings at hatching rising to 75 square feet at 3 to 4 weeks. Clean straw forms the best litter, and this should be renewed every 10 days. After 3 to 4 weeks the ducklings can be transferred to rearing houses of simple construction, a house 6 feet by 6 feet being suitable for 50 ducklings.

The houses should be placed in grass runs, an area 12 yards by 12 yards giving sufficient accommodation. 18 inch wide wire netting is sufficient to keep ducklings confined, and 2 feet wire netting will confine adults. At 8 weeks of age, ducklings intended for breeding are separated from those intended for fattening. The ducklings intended for breeding are given a mash similar to the laying mash, but with only half the amount of fish meal. The mash and grain are also fed sparingly, to encourage grazing, and the birds are given full liberty. Those intended for fattening are put on a fattening mash, and can be conveniently grouped into batches of 300 and confined to a grass run 25 yards by 25 yards.

Temporary shelters made out of double hurdles packed with straw and fitted with a light roof will give the fattening ducklings all the shelter they need. The shelters are three-sided with the fourth side open away from the prevailing wind.

Feeding.

During the first week the ducklings can be fed on wet mash 5 times daily, only as much mash being fed as the ducklings will clear up, since stale mash may lead to losses. During the next three weeks the number of meals a day can be reduced to 4, thereafter 3 meals a day will be sufficient.

Suitable rearing mashes for the period up to 8 weeks are:

Rearing Mashes to 8 weeks.

	1.	2.
Bran	20	20
Weatings	15	40
Sussex ground oats ..	12	20
Maize meal	40	10
Fish meal	—	10
Meat meal	10	—
Salt	½	—
Ground limestone ..	1½	—

At 8 weeks the ducklings are changed over to a fattening mash and given 3 meals a day. Suitable fattening mashes are:

Fattening Mashes from 8 to 10 weeks.

	1.	2.	3.
Weatings	25	15	20
Barley meal	18	—	70
Maize meal	25	40	—
Sussex ground oats	25	—	—
Dried skim milk	7	—	5
Meat meal	—	—	4½
Tapioca flour	—	15	—
Oatfeed*	—	15	—
Butchers' greaves†	—	15	—
Salt	—	—	½

* *Oatfeed.* A by-product obtained in the milling of oats. The crude protein content varies from 2 to 3·5%, the crude fibre from 24 to 26%, and the soluble carbohydrates from 54 to 63%.

† *Butchers' Greaves.* A by-product obtained during the "rendering" of meat residues to remove the fat. Is essentially a feeding meat and bone meal and is generally rich in fat.

Fresh water and a box containing sand should be available at all times. Careful attention is needed to see that the ducklings are picked up for marketing at the right time, since if moulting begins, several weeks will elapse before the birds again reach marketing condition. This stage of moulting begins about the end of the tenth week, but is materially affected by weather conditions.

THE FEEDING AND MANAGEMENT OF GEESE

Geese are raised in this country in small flocks on general farms, and can most successfully be raised to yield a profit on farms where there is plenty of pasture and grass and access to water. Geese are very hardy, excellent and close grazers, and are not susceptible to disease. Their requirements for housing are also very slight, shelter only needs to be provided in winter and in stormy weather, with some provision for shade in the summer months. Both goslings and mature geese will obtain practically all their food requirements from the pastures on which they range, except in the winter, when mash and grain feeding becomes necessary. While grazing, an occasional light feed of grain is all that need be provided. Geese intended for the Christmas market can be folded like sheep on turnips or swedes from October 1, it being customary to split each swede to facilitate feeding. Three weeks before killing the birds are penned and fed on wet mash, the mashes recommended for fattening ducks (page 314) being suitable for this purpose.

Goslings can most easily be raised under hens, 3 to 7 eggs being set, the number depending upon the size of the hen and the time of the year. The eggs need to be hand turned daily, as the eggs are too large to be conveniently managed by the hen. The period of incubation varies from 30 to 35 days. The goslings are fed for the first time 36 to 48 hours after hatching, and should be confined to a good grass run for the first two or three weeks in coops fitted with board floors. They should be kept confined in the coops in the mornings until the dew is off the grass, since young goslings are very susceptible to damp or wet; nor should they be allowed access to swimming water until they are partially feathered, that is, until they are 2 to 4 weeks old. They should be fed on wet mash, the mashes recommended for ducklings (page 314) being suitable. Whole grain should not be fed until the goslings are well feathered. On good grass the goslings will need little feeding after 3 weeks of age until they are brought in for finishing.

THE FEEDING AND MANAGEMENT OF TURKEYS

The foundation of successful turkey raising is the breeding flock. The utmost care should therefore be exercised in the selection of breeders, which selection should take place during November or December. The breeding flocks are normally allowed free range, but owing to the difficulty of locating nests, the practice of keeping the breeding flocks during the egg laying season in large breeding pens is now commonly practiced. A pen 25 square rods in size will suffice for 12 to 15 birds, and pig proof wire fencing 5 feet high will usually confine the birds satisfactorily. 10 to 15 females are mated to a young vigorous tom, the spurs of the tom being trimmed smooth to avoid injury to the females during mating. Yearling hens or early hatched pullets should be used as breeding stock. The normal breeding season begins in late winter and continues until June, a young turkey hen during this time should produce from 40 to 50 eggs. During the summer and autumn months the breeding flock should be allowed free range, a daily allowance of grain at the rate of 5 ounces per female and 10 ounces per tom being fed in addition. A mixture of equal parts of maize, wheat and oats will be suitable for this purpose. During the laying season dry mash should be available at all times in suitable hoppers, and a daily grain feed at the rate of 4 ounces per breeding hen, and 8 ounces per tom should be given as an afternoon feed. Any cereal grain mixtures can be used, selected from oats, barley, wheat or maize. The following mash mixture will give good results:

Mash Mixture for Breeding Stock.

Maize meal	30 parts by weight
Bran	10
Weatings or middlings	22
Dried skim milk	15
Meat meal or fish meal	10
Lucerne meal	7
Oyster shell, or ground chalk, or limestone flour	4
Steamed bone flour	1
Salt	1

If dried milk is scarce or dear, it may be replaced by 10 parts of fish meal, making the fish meal in the total ration, 20 parts.

The addition of green food is desirable, and if plenty of green food

is given and the birds have access to abundant supplies of sunshine, the cod liver oil and the lucerne meal may be omitted from the above diet.

The Rearing and Feeding of Turkeys for Market.

Owing to the losses occasioned from blackhead when turkeys are brooded and reared by natural methods, intensive systems of rearing turkeys for market are now often practised. The methods of management used are similar to those used in the intensive rearing of chicks, colony houses or permanent brooder houses fitted with sun parlours being used.

Turkey chicks or poults require more accommodation than ordinary chicks, and care should be taken to see that they are never crowded. For intensively reared birds, a good working rule is to allow 2½ square feet per bird up to 7 weeks, 5 square feet from 8 to 16 weeks, and 10 square feet thereafter. Poults can be conveniently reared in batches of 75 to 125, but should never exceed this number. Low, flat roosts 3 inches wide should be placed in the brooder when the poults are 2 to 3 weeks old, to encourage roosting and to danger the risk of losses through crowding at night. The feeding troughs for the first week can be constructed from 1½ to 2 inch laths, from 2 to 4 weeks the troughs should have 2½ inch sides, from 5 to 8 weeks 5 inch sides, thereafter the feeding troughs should have 8 inch sides slightly tapering towards the top, with a six inch base. A convenient length for the trough is 4 to 6 feet. One foot of feeding space should be allowed for every 4 or 5 birds.

Feeding.

A mash and grain system is the usual practice, the mash being fed either wet or dry. Mash feeding only during the brooder period is often practiced, followed by grain and mash feeding during the growers' period.

If wet mash feeding is adopted, 5 meals a day are given during the first week, 4 meals a day from the 2nd to the 12th week, and 3 meals a day from then on. Finely chopped green food, such as clover or other low fibre containing green food is given during the brooder period in green food hoppers, and kale thereafter until fattening commences.

The following mash and grain mixtures have been used successfully for intensive systems:

1. *Starting mash to 12 weeks*	(all mash) (dry fed)	*Growers' mash to fattening* (grain and mash) (dry fed)
Maize meal	25	20
Middlings or weatings	17	36
Dried milk	17	6
Bran	10	10
Sussex ground oats	10	10
Fish meal or meat meal	9	11
Lucerne meal	5	3
Ground oyster shell	2	3
Sterilized steamed bone flour	2	—
Salt	1	1
Cod liver oil	2	—

Grain

Wheat	1
Kibbled maize	1

Both grain and mash were fed *ad lib* in hoppers.

2. *Starting mash to 8 weeks*	(wet mash and dry mash)	*Growers' mash to fattening*
Maize meal	20	20
Weatings	35	35
Bran	14	20
Sussex ground oats	10	10
Lucerne meal	5	5
Meat meal	3	—
Soya-bean meal	5	6
Dried skim milk	5	3
Salt	1	1
Cod liver oil	2	—

Grain.

0 *to* 6 *weeks*		6 *weeks to fattening*	
Pinhead oatmeal*	1	Wheat	1
Maize grits	1	Kibbled maize	1
Cut wheat†	1		

* *Pinhead Oatmeal.* A form of oatmeal, the particles of which approximate in size to that of the head of a pin.

† *Cut wheat.* Wheat, the kernels of which are cut into two or three pieces.

For the first fortnight the birds were given 4 feeds a day of wet mash with light feeds of grain morning and evening. After this period, two wet mash feeds a day were given, grain morning and evening, with free access to dry mash at all times. Suitable graded oyster shell was given in hoppers.

3. *Starting mash to* 10 *weeks*	(wet mash)	10 *weeks to fattening*
Weatings	30	34
Maize meal	20	24
Bran	20	22
Sussex ground oats ..	10	11
Lucerne meal	6	—
Fish meal or meat meal	6	7
Dried skim milk ..	6	—
Salt	1	1
Cod liver oil	1	1

Grain

(Mixtures as above).

The system of feeding is as given above, except that instead of two feeds of wet mash daily after the second week, 4 feeds a day are continued until the 12th week, after which 3 feeds a day are given. Suitably graded oyster shell is given as described above.

Fattening Mashes.

For a period of 4 weeks before marketing the birds are given 3 full feeds a day of wet mash. If grain is given in addition it should be soaked several hours before feeding and is preferably given as the last feed at night. Any mixture of cereal grains ground to a coarse meal is suitable as a fattening mixture, provided that barley or oats or a combination of the two does not form more than 40% of the total mixture, and provided that it is fed with 15% of dried skim milk or meat meal. Fish meal should be avoided in the fattening mixture as it is likely to taint the flesh.

Turkeys will fatten successfully on cereal grain mixtures alone if fed in conjunction with unlimited supplies of fresh skim milk to drink. The milk should be fed in easily cleanable stoneware troughs which should be kept sweet and clean.

XVI

FEEDING IN WARTIME

IN time of peace the farmer's aim is to feed his stock as cheaply as possible ; this has resulted in many instances in the farm being used to provide roots, grassland, and grassland products, these products being supplemented with cheap imported concentrated foods. In wartime the nation requires farmers to produce the maximum quantity of direct human food per acre, and at the same time to be as self-supporting as possible. Since the outbreak of the war the imports of concentrates have declined so seriously that only very small quantities have been available for pigs, poultry, and other stock, it being recognized that dairy cows should have priority of supply because milk was so essential for the consuming public. Wartime feeding has resulted in great economy being made and foods that in peace time were wasted have been fed to livestock. In order to obtain maximum production farmers were made to plough up grassland because on examination it is found that arable land produces more nutrients per acre than does the same land under grass. Some readers may question this statement, but Table XXXVIII will demonstrate this point adequately.

In the table grass yield as hay is put as high as possible and only good average figures are given for the arable crops. It will be seen that the highest yields of food are obtained when the root crops are grown. Thus wartime feeding consists primarily of using less concentrated foods, of growing and utilizing the maximum quantity of root crops, of making the greatest use of grassland and its products, of seeing that no edible material is wasted, and that the strictest economy be exercised in the feeding of all livestock.

In normal times vast quantities of feeding-stuffs are imported into this country for feeding to livestock. The normal imports run to some 8½ million tons per annum and consists of some 80% carbohydrates, the remainder being protein feeds.

When space in ships is limited it seems more sensible to import the finished human foods rather than the basic foods for stock feeding to produce those foods; about 5 lb. of concentrated foods are

TABLE XXXVIII

FOOD OBTAINED PER ACRE FROM VARIOUS CROPS

Crop	Yield in Tons per Acre	Nutrients per Acre			
		S.E. (lb.)		P.E. (lb.)	
Grass (best hay)	2·5	2,688		437	
„ (poor hay)	2·5	1,232		162	
Lucerne (3 cuts) (green)	12·0	3,024		806	
Silage (medium)	12·0	3,494		538	
Kale	20·0	4,032		582	
Mangolds	30·0	4,704		269	
Beans,—straw	2·0	1,030	2,952	76	658
„ grain	1·3	1,922		582	
Oats,— straw	1·5	672	2,352	30	254
„ grain	1·3	1,680		224	
Wheat—straw	2·0	582	3,001	45	381
„ grain	1·5	2,419		336	
Maize (green)	20·0	4,077		358	

required to produce 1 lb. live weight of pigling (allowing for the sow), this becomes 8 lb. for 1 lb. dead weight when the killing percentage (75%) is allowed for, and 10–12 lb. of meal for 1 lb. of bacon when the shrinkage during curing is taken into account. Further it means that the livestock that depend more especially upon the imported feeding-stuffs must be those most especially considered, e.g. pigs, poultry and possibly dairy cows.

There has also been a tendency of later years for farmers to develop pig, poultry and dairy production on factory lines, they themselves buying all the feeding-stuffs required. Although these "animal factories" may be quite satisfactory in normal times, in war-time they are a nuisance since they produce no feeding-stuffs for their own use and cannot be self supporting. It is very difficult for even mixed farms to be self supporting, for although it may be relatively

easy to produce a variety of carbohydrates, namely, roots and cereals, but regulations may prevent farmers from using some of the cereals they have grown. So far there are no restrictions upon the use of home-grown oats, and all roots with the exception of potatoes and sugar-beet can be used as the stock feeder likes. Also there are no restrictions upon the purchase and use of potatoes for stock feeding ; this has proved an invaluable concession to pig breeders and poultry keepers. Stock keepers can grow some protein foods but it is difficult to grow a variety. On heavy soils beans may be grown, but it seems that yields are very variable, for climate influences production. On medium soils beans or peas may be grown, whilst on light soils peas are the only pulses that will give satisfactory results. On the very light soils even peas cannot be grown because they give such bad yields. Other ways of increasing proteins are to grow such foods as tares and oats, kale, and lucerne, since they are all relatively rich in proteins. Also cutting hays when they are relatively young give richer foods though yields are reduced. It should be pointed out that in our earlier chapter peas and beans are described as excellent foods, even better than their chemical analyses suggest because of their amino-acid content.

It is absolutely essential for farmers to plan their feeding carefully because supplies of imported concentrates are very variable as regards both quantity and type. Even with careful planning there is the chance that sudden changes may be enforced in feeding the various farm animals and everyone who has handled livestock knows that such sudden changes lead to detrimental effects upon growth, fattening, and yields of milk production, and should, in consequence, be avoided whenever possible. Thus the more the feeder can be self-supporting, the less is his dependence upon purchased feeding-stuffs, and the greater the reduction of the risk of suddenly changing rations. As far as possible farmers must plan their cropping at least 12–24 months before crops are to be used ; in the case of seeds the planning must be done 12 months earlier, namely, 24–36 months before the food is to be consumed.

Of the root crops that are most widely grown in this country kale and mangolds can usually be relied upon to produce the greatest amounts of food per acre. It so happens that these two foods are available for feeding during many months of the year; kale can be available from August to February or even March (depending upon the time of drilling) and mangolds from January to May and June and in exceptional cases till July (it being remembered that mangolds are not safe to feed till about January). In Scotland and the North of

England where the climate is too severe for mangolds and kale, swedes may be grown and although the yield will not be as heavy as that for mangolds the feeding values of mangolds and swedes are similar so that no special differences need be made in considering roots in the rations. If green soiling crops are required to ensure a supply of "roots" in June and July cabbages may be grown and fed, or even second growth from cabbages, grown primarily for human food, may be used. For August and September no crop will produce more nutrients per acre than will maize if the season has suited it.

There is no doubt that grassland is rarely used to its greatest advantage. If it is undergrazed the vigorous, unpalatable grasses quickly predominate and the grassland rapidly deteriorates; well managed, heavy grazing usually encourages the better grasses since the vigorous growing grasses are kept down. It is also well known that young grass is richer in food values than older grass: thus any management that increases the production and utilisation of young grass is to be recommended. One of the easiest ways of encouraging young grass is by nitrogenous manuring: the young growth produced is especially valuable if obtained in early spring before normal spring growth has commenced. Whenever there is a slight surplus of grass it should be removed and if stock are not available then it should be preserved by drying it or by making it into silage. The latter demands very little capital outlay whereas the former demands so much that few can try it.

The ploughing up campaign must of necessity reduce the amount of hay that is made and it will invariably increase the quantity of straw obtained. This, up to a point, is most fortunate since it ensures an adequate supply of coarse fodder for the class of stock requiring that feeding-stuff. The change, however, results in a loss of protein foods: whereas the hays may be relatively rich, the straws are relatively poor, in protein. It should also be remembered that the straws, especially wheat, may not be very palatable and they are not easily digested. In wartime appeals have been made to chemists to see if it is possible to pre-digest straw and so make it of greater value to stock. Pre-digestion has been effected by:

(*a*) steaming in open vessels or under pressure.
(*b*) boiling or stewing with alkali in open vessels.
(*c*) cooking with alkali under pressure.
(*d*) cold treatment with acids and such alkalis as caustic soda, caustic lime, or chlorine peroxide.

Of all these treatments the most practicable consists of soaking chopped straw in a 1·5% solution of flaked caustic soda. The soaking period varies from 3 to 22 hours, but when the short period is permitted the pulp must be left on the ramp to drain so that in effect the soaking continues for a further period. This treatment has increased the starch equivalent value of straw :

Wheat straw by	110%
Barley straw by	57%
Good Oat straw by	37%
Very best Oat straw by	26%
Chaff and cavings by	26%

It will be observed that peas and bean straws are omitted and any straws containing seeds should not be treated with caustic soda since the treatment results in proteins being wasted, and these foods contain proteins. In order to treat 1 ton of dry straw it should be cut into 2- to 3-inch lengths and 180 lb. of caustic soda and 6,000* gallons of water will be needed and 10 man hours' labour will be taken. Whilst such treatment increases the nutritive value of the straw it cannot make straw equal in value to good hay ; this treatment really changes straw into roots. Chemists are, however, attempting to increase the food value of the straw still further by adding urea to it, but the full details of the treatment are not, as yet, available.

To meet the shortage of milk for the consuming public a new food known as National Calf Starter was introduced for feeding to calves. This food was essentially concentrated and was to be used instead of milk by making it into a gruel. In peace time a special pedigree calf may receive several hundred gallons of milk, but many calves are given 30 to 80 gallons ; by using this National Calf Starter the milk consumption may fall to as low a level as 10 gallons. Not only does this conserve milk supplies, but it reduces the cost of rearing because the calf starter made into a gruel will cost only three- to fourpence per gallon, whereas the milk it replaces will be worth well over 2s. per gallon. It has been shown that excellent results can be obtained by using this national food, but certain precautions must be taken if the greatest success is to be achieved. The method of mixing the gruel is to take the meal and add a little cold water, stirring all the time to make a thick paste, more water is then added so that 2 quarts of water are added to each lb. of meal. The mixture must be boiled for 2 minutes, stirring taking place all the time. A further 2 quarts of water may be added to each original lb. of meal to thin the food and to cool it down to

* This large quantity is necessary since the bulk must be washed thoroughly because badly washed straw is very unpalatable.

the proper temperature for feeding. It is possible to dilute half the gruel for immediate feeding, and to retain the other half for a subsequent feed when the latter will be warmed by adding 2 quarts of hot water to each 1 lb. of meal. The gruel feeding is usually commenced when calves are three weeks old, the quantity fed being increased to replace milk till no whole milk is given after the calf is four weeks old. The maximum quantity of gruel feeding is reached at the sixth or seventh weeks and then the ration is gradually reduced till none is fed after the normal calf is about ten weeks old. In all other respects the feeding may be just the same as in peace time, but of course the pre-war foods such as flaked maize are not available and another special mixture may be purchased, and this is known as National Calf Starter Cudlets. Owing to the shortage of foods it is essential that none should be wasted and that stockmen should take pains to make sure calf pens and utensils are kept clean because that will help calves to remain healthy and healthy calves make the best use of all foods they are given. When calves are scouring, food is being wasted.

It is not possible to feed straw to calves under three months of age, and it is unusual to find any fed to calves till they are six months of age. Older stock usually receive large quantities of straw, and it is rarely possible to increase straw consumed by such stock in wartime. The feeding of dairy cows may be modified to increase slightly the quantity of bulky foods given and the concentrated foods may be saved. Low yielding and nearly dry cows may be given fairly large quantities of roughages. Very little extra straw can be fed to fattening cattle.

Economies in the use of concentrated foods for dairy cows and increased quantities of roughages and roots are suggested in the Tables XXXIX and XL;the minimum of concentrates are suggested and the new ration of S.E. to P.E. of 5 to 1 is used. From these two latter it will be seen that instead of feeding a maintenance ration and 3 to 4 lbs. of concentrates per gallon of milk it has been possible to utilize only a small quantity of concentrates and in some cases only home-grown concentrates have been included, e.g., beans. It is suggested that these rations be used only for cows giving yields of not more than 3 gallons daily ; with higher yields normal maintenance rations as suggested on page 190 should be used. The production rations will be the same as in peace time as shown in page 194, but of course some of the foods mentioned may not be available.

TABLE XXXIX

DAILY RATIONS TO PROVIDE MAINTENANCE AND THE NUTRIENTS FOR THE PRODUCTION OF 1 GALLON OF MILK

Food	Pounds per Day				
	Ration A1	Ration B1	Ration C1	Ration D1	Ration E1
Medium meadow hay ..	12	12	—	7	7
Oat straw	7	7	14	—	10
Mangolds	40	35	40	35	—
Beans	2	—	—	—	—
Oat and tare silage ..	—	20	30	30	20
Marrow stem kale ..	—	—	—	—	25

TABLE XL

DAILY RATIONS TO PROVIDE MAINTENANCE AND THE NUTRIENTS FOR THE PRODUCTION OF 2 GALLONS OF MILK

Food	Pounds per Day				
	Ration A2	Ration B2	Ration C2	Ration D2	Ration E2
Medium meadow hay ..	17	12	—	7	10
Oat straw	—	—	14	—	—
Mangolds	50	20	40	40	—
Beans	2	2	—	1	—
Dec. ground-nut cake ..	1	—	1	—	—
Oat and tare silage	—	30	30	40	40
Marrow stem kale ..	—	—	—	—	30

Little need be written on the subject of feeding dairy cows in the summer time because wartime feeding will differ very little from feeding in peace time, save that owing to the ploughing up campaign the cows will be more dependent upon the produce of arable land. This may lead to increased use of green soiling crops, such as are given on page 207 (in Table VII), or possibly silage may be used, or straw pulp may be prepared for feeding. It must be admitted, however, that the increased use of green soiling and silage crops is unfortunate since they need extra labour to grow and to feed them to livestock and labour supplies may be very limited on some farms.

Fattening of cattle in wartime is very different from fattening in peace time because in the first instance prices paid for fat beasts are for quantity and not quality, which is, of course, the exact opposite of the peace time scheme. This means that the only beasts farmers are encouraged to fatten are the mature stock that are fattened on grassland or in yards. The pre-war veal that was fed on a liberal ration of whole milk has disappeared, and so have all beef cattle that were fed principally upon concentrated foods. A reduced number of beeflings have been kept. For the fattening of cattle in yards wartime feeding demands the maximum use of roots rather like what is known as the old fashioned system of root feeding. This change was inevitable because very little concentrated foods were available for feeding to cattle and no rations of concentrated foods were given by the War Agricultural Committees. These changes did not lead to much variation from the schemes suggested in Tables X (p. 218), XII (p. 220), and XIII (p. 221). The reduction in concentrated rations available slowed down the rate of fattening ; the most common time for cattle to take to fatten is six months.

For fattening on pastures the same class of stock is needed to-day as before the war. The area of grass available for these stock is much reduced ; this may result in a reduction in the number of cattle that may fatten on nothing but grass. Unfortunately, extra concentrates cannot be issued and farmers are forced to fatten their stock on tail corn and oats, but the quantities available may be relatively small and rates of fattening may be slow. This may result in some cattle not being fat for sale in the autumn when the grass deteriorates and fattening of these stock may have to be completed indoors.

Turning to sheep it is impossible to make material economies in feeding concentrates, for many sheep do not receive any at all, whilst those that do eat concentrates consume roots in very large quantities

and further increases are not practicable. The only place where economies might be made is with grassland flocks. In such cases concentrates are sometimes fed in the spring before the grass has made much growth. It is possible, by the careful use of nitrogenous top dressings to obtain 2 to 4 weeks earlier feed; this may easily save the feeding of concentrates. Alternatively roots and hay may be given at such times in the spring if grass or concentrates are not available. There is no doubt that grassland sheep farmers do not make the fullest possible use of root crops, such as mangolds and swedes, as means of saving cereals. The arable land breeds of sheep seem to demand heavy rations of concentrates and they do not thrive without them; economies are difficult but a greater use of hay would serve to reduce the demand for concentrates. Usually shepherds are loath to use hay and prefer concentrates, possibly this may be because the latter is much easier to handle when feeding it to the flock.

Everyone in this country knows that working farm horses must have oats, but very few seem to realize that economies may be made by reducing the ration of oats and by replacing them with roots. In the Fenland districts mangolds are regularly fed to working horses (and the Shire horses found in these districts are a credit to their breeders and feeders). There is no reason why this practice should not become more widespread. Any economy in feeding oats would liberate them for dairy cows, which everyone admits must be well fed in order to maintain milk supplies. It is not necessary to pulp or slice mangolds, for horses will eat whole ones quite readily. Horses must have mangolds introduced gradually to their rations otherwise scouring may ensue. When they become used to them big working horses will eat 40 lb. roots per day, thereby resulting in a saving of some 4 lb. of oats daily. Young horses, e.g., yearlings and two-year-olds can eat 20–30 lb. daily when housed in winter—hence a corresponding saving may be made. It may be possible to give silage to horses whether young or old ; the stock like it and their coats look well when they have it. Two-year-old horses could eat about 15 lb. of seeds or similar silage daily.

The modern pig has been developed to live principally on concentrated foods whereas the wartime pig is required to depend less and less on such foods and more and more upon bulky succulents. It is impossible to make all pigs consume large quantities of succulents but sows in particular are most fitted to deal with such foods. In peace time some farmers run all breeding pigs on the outdoor system where the pigs eat sufficient grass in summer to effect a saving

of 6 lb. of meal daily per sow. It is also possible to fold sows on arable land (especially now that electric wire fencing has been proved to be so successful for this purpose) on such crops as seeds leys, lucerne, oats and tares, cabbages, kale, rape, sugar-beet tops, etc. Also these crops may be cut or pulled and fed to housed sows, if that should prove more convenient than keeping pigs on the arable land, or carted, in times of drought, to sows running on pasture. By such means one is less dependent on grass and in some cases the crops may be consumed late into the winter. Potatoes, mangolds and swedes, may be carted to housed sows in winter or those that remain at grass, which actually, at that time of the year, provides nothing for them beyond an exercising ground. The quantities of these foods that may be given daily may be as high as 30 lb. ; this in the case of cooked potatoes may effect a saving of 7–8 lb. of meal since 4 lb. of cooked potatoes have been found to be of equivalent food value to 1 lb. of barley meal. Much experimental work has been done which shows that potatoes pay handsomely for the cost and trouble of cooking them. On various occasions attempts have been made to feed sows on silage but usually it has proved too fibrous for them to make good use of it. One special kind of silage, namely from cooked potatoes, has proved satisfactory but this is so much like ordinary cooked potatoes that such a result would have been anticipated. Finally mention can be made of hotel swill since it is quite satisfactory for feeding to sows (see Chapter XIII).

As a wartime measure a number of the large towns in this country arranged to collect edible scraps from the householders in their respective towns. In some cases this foodstuff was cooked and fed to pigs kept by the town or city corporation or similar bodies ; in other cases so much food was collected that special plants were installed to cook the material where the supply exceeded the local demand. In the process of cooking the waste loses a large part of its moisture and on cooking in the containers it sets to a firm stiff " pudding " which finds a ready market for feeding to pigs and poultry. Since this " pudding " was first produced in the Tottenham district of London such prepared food is known as " Tottenham Pudding." Owing to the shortage of ordinary meals for pigs' feeding the Tottenham Pudding became so popular that quickly the demand exceeded the supply and prices rose. Other Town Councils saw the financial results likely to arise from the cooking and drying of the Tottenham Pudding, and many installed the necessary plants. This pudding is so dry that it can be sent out to farmers by rail in sacks. Since the " pudding " had been cooked it

was fed to pigs without any further cooking. Undoubtedly the "Tottenham Pudding" was good food for fattening and breeding pigs provided it did not contain such foreign materials as broken glass, crockery and pieces of iron and nails.

Suckling pigs have very delicate digestive systems and it is folly to force them to eat unusual foods, certainly not in large quantities. No harm will arise, however, if they more or less steal food from their dams. In this way the quantity they will eat will be small, especially if they, themselves, are fed meals in creeps. After weaning, and until piglings are about 60 lb. live weight, i.e., when about three months old, their digestive systems cannot cope with bulky succulent foods; if the latter are fed the pigs grow slowly and make poor use of the meal foods that are actually given. In effect the meal is wasted and since the succulents are fed as well nothing is gained by the feeding of roots. The only succulent foods that young piglings may benefit from are small quantities of those they have received while suckling. Thus if piglings have been on grassland while suckling they will do well on grass after weaning provided they do not remain there for fattening. If they have been used to eating small quantities of kales, cabbages or mangolds, such foods may be continued, but the ration will be only of the order of a few pounds daily.

Fattening pigs can make good use of cereal substitutes provided they are gradually accustomed to the new rations. Table XLI shows the relative values of the various roots for feeding to fattening pigs; there it will be seen that many of the roots are really very unsuitable for pig feeding since so much is required to produce 1 lb. live-weight gain, and rarely can a pig consume more than 15 lb. of the succulent food. Contrary to the opinions of many pig feeders experience has shown that pigs may be fattened quite satisfactorily on as little as 2 lb. of meal daily, and in a few special cases when good quality swill is available no meal has been fed to pigs after they have been three months of age. The succulent foods should be given in two feeds daily in conjunction with meal rations, but it should be remembered that in winter time frozen roots, if fed, may easily lead to scouring. It appears that the feeding of these green foods often results in slowing down the rate of fattening; the above figures take this fact into account where the food value of the foods is assumed. Some readers may be surprised to learn that artichokes

TABLE XLI

ROOTS FOR FEEDING TO FATTENING PIGS—GIVING DETAILS REGARDING FEEDING

FOOD	Form in which Fed	Lb. Food Equivalent to 1 lb. Barley Meal	Maximum Quantity to Feed daily (lb.) (By 200 lb. Live Weight)	Percentage of Protein Equivalent
Potatoes	Steamed or Cooked	3·4	30 *	0·8
S. Beet (Roots)	Steamed or grated	3·3	10	0·5
S. Beet (Tops)	Green with ¼ lb. chalk to 300 lb. tops	10·0	15	1·1
Kale	Green	7·2	15	1·3
Rape ..	Green	9·0	15	1·6
Mangolds ..	Whole	10·3	10	0·4
Swedes ..	Sliced	7·3	10	0·7
Cabbage (Drumhead)	Whole and raw	7·4	10	0·9
Grass	Cut green	6·5	14	2·2

* More can be fed but the stock become pot-bellied which makes them very thin in the streak.

have been omitted from the above table (purposely) because experts have shown that they are not well digested by pigs. If they are to be fed to pigs they should not be cooked, they are more easily digested in the raw state. Pigs will "dig" their own artichokes if they are given an opportunity of doing so.

The table shows that some of the succulents are much richer in protein than are others thus they cannot be used indiscriminately to replace barley meal in pig rations. All "greenstuff" with less than 1% of proteins should be fed in conjunction with high protein meals whereas the green foods with over 1% do not demand such high protein levels. This is best illustrated as follows:—

Meal for use with succulents:—

A. *High protein meals.*

10% Meat Meal.
30% Weatings.
20% Dried Sugar-Beet Pulp.
40% Oat Meal.

Or—

30% Bean Meal.
30% Weatings.
10% Malt Culms.
28% Oat Meal.
2% Minerals.

(And see Chapter XIII)

B. *Low protein meals.*

5% Fish Meal or Meat Meal.
20% Weatings.
20% Malt Culms.
20% Dried Sugar-Beet Pulp.
35% Oat Meal.

Or—

10% Bean Meal.
20% Weatings.
15% Dried Sugar-Beet Pulp.
15% Malt Culms.
38% Oat Meal.
2% Minerals.

(And see Chapter XIII.)

It is always essential to see that all meal is used efficiently but it is even more important to see that none is wasted in wartime. It is not well appreciated by pig keepers that it may be a mistake to give pigs all they will eat when they are being fattened for bacon production. 200 lb. pigs will eat up to 9 lb. of meal if they are given the chance, but the food is not used efficiently and the pigs are inclined to get too fat. Depending on the season of the year, and breed or cross of pig involved, the maximum daily requirements for bacon pigs of 200 lb. live weight is certainly not above 7½ lb. of meal per head daily. Some pigs have been fattened successfully on lower levels than this, namely on rations that have never exceeded 5½ lb. per head daily. The lower level of feeding leads to slower fattening, and even when allowance is made for the longer time required for fattening, there is often a saving of some 50 lb. of meal in the fattening of a bacon pig by restricting the maximum daily ration to 5½ lb. as opposed to the more usual 7½ lb. The pig that has been fed on the lower level is a leaner pig when ready for killing at 200 lb. live weight. Thus war-time feeding will lead to slower growth for the above rations may be further reduced when meal is replaced by potatoes or swill so that under 2 lb. of meal may be given per pig per day. Provided growth is not too slow, the slower growth produced by wartime feeding appears to be quite sound, since it will lead to a leaner carcase than that produced when pigs are fattened as rapidly as possible.

In wartime it may be necessary to change the ages at which pigs are killed in order that the pigs shall consume the foods that are most abundant, e.g., a pork pig killed at 100 lb. live weight will have eaten nothing but concentrated foods whereas a pig killed at 200 lb. may have consumed several hundred pounds of roots or green food. Since the bigger pigs can consume relatively even more greenstuff or roots it may be in the national interest for the pigs to be retained till they reach 300 lb. before they are slaughtered. A pig killed at 200 lb. live weight will have consumed about 6 cwt. of concentrates if no supplements are used, or $3\frac{1}{2}$ cwt., the remainder being roots, to produce 140 lb. of carcase, whereas a pig killed at 300 lb. may have consumed only 4 cwt. and supplementary foods, and will give a carcase of 230 or even 240 lb. No further comment is needed.

The class of stock most likely to be severely affected by lack of supplies during wartime is poultry. This is due, not only to the fact that the foods normally used for poultry feeding are largely imported, but also to the fact that the home grown foods such as wheat, barley and rye, that are used in poultry feeding during times of peace, are diverted to the flour milling and brewing industries. In addition, the pig competes with the hen for such supplies of feeding-stuffs as are available. From the national point of view, it has been shown that more human food in the form of meat is produced by the pig than by table poultry from equivalent amounts of feeding-stuffs. On the other hand, human food in the form of eggs is as economical to produce as either pork or bacon, and since dietetically eggs are much more suitable for children and invalids and much richer in vitamins and health promoting qualities, it is of national importance to maintain home egg production at as high a level as possible, even though it may result in lessened pig production. The policy of keeping up pig production at the expense of egg production, and importing such supplies of eggs as are necessary is inherently unsound, since the shipping space so utilized could be better used for the importation of pig products; not only would more human food be thus imported into the country in the same amount of shipping space, but the relative cost of a unit of food would be much less.

It can therefore be assumed that during wartime the agricultural policy of the country will be to maintain egg production but to discourage poultry meat production. In addition, the economic strain of the war will result in making it very difficult for those keeping poultry on intensive lines to compete with those keeping them on extensive conditions. As a consequence, an increase in farm reared poultry and a decrease in specialist poultry is likely to ensue.

Substituting Feeding-Stuffs in Wartime.

It will be noted from the rations given in Chapter XV on the feeding of poultry that, in normal times the mash is composed almost entirely of the following feeding-stuffs:—maize meal, bran, weatings, Sussex ground oats, dried yeast, dried skimmed milk powder or fresh skimmed milk, buttermilk powder, dried whey, fish meal, meat meal, or meat and bone meal. The grain mixtures consist almost exclusively of wheat, oats and maize. During wartime, bran, weatings and maize meal will be in short supply, the use of wheat fit for milling is bound to be either restricted or prohibited for use by livestock, and fish meal, meat meal and meat and bone meal, are also likely to be in short supply. The seriousness of the position from the point of poultry food supply can be appreciated when it is realized that 30% of the total ration consists of wheat offals, 17% of wheat, and 27% of maize and maize meal. Moreover, if the whole of the offals obtained by milling the entire wheat crop of England and Wales were retained exclusively for poultry it would form only 15% of the total ration, with tail corn forming another 5%. It is obvious, therefore, that a certain amount of imported food supplies must be allowed in if the poultry population is to be maintained at the pre-war level. The poultry farmer must therefore economize in the use of imported feeding-stuffs by use of home-grown substitutes and other feeding stuffs not normally fed to poultry. In order to act as a guide to such substitution, brief notes on such substitutes and the extent to which they can be used in substituting the normal ingredients of the ration are indicated.

The first, and most obvious step to take is to switch over from intensive and semi-intensive systems of poultry-keeping to a free range system, since full advantage of grassland and food products available on free range is thereby obtained. It has been shown that poultry can be stocked on such land at the rate of 50 to the acre without affecting the value of such land for other livestock, and it is estimated that poultry can obtain from 10 to 15% of their food requirements by so doing. The next step is to make full use of home grown products such as chat potatoes, roots, green foods and silage, and other feeding stuffs such as beans, rye and oats, that are likely to be available as the result of the ploughing up of grassland. In this connection, the introduction of buckwheat as a catch crop on the lighter soils might well be worth while.

The use of such substitutes should be confined to growing and laying stock, keeping the chick rations as near normal as circumstances will allow. The reason for this is that growers and layers can deal more effectively with such substitutes than can chicks, in addition, the amount of food consumed by chicks in the first eight weeks of their lives is so small that such substitution is hardly worth while. Nevertheless, it should be remembered that if supplies of fresh milk are available, chicks can be successfully reared on cereal mixtures with milk available as their liquid sustenance.

Substitute Feeding-Stuffs.

1. *Grain substitutes.*

Oats are likely to be in normal supply and can form up to one-third of the grain ration. Wheat may or may not be available; if available, the grain ration can consist entirely of wheat and up to 25% of the mash. Oats can also be included in the mash up to a 25% level, they must be finely ground. Other grains likely to be available are buckwheat, barley, rye, dari and millets of various kinds. Dari and the millets are akin to wheat in feeding value and can be used freely as wheat substitutes. The smallness of the grain makes these grains suitable for inclusion in chick diets. Buckwheat is a grain that has gone out of use but was highly esteemed in the past both for feeding to chicks and layers, and in the form of meal for fattening. It may form up to 20% of the grain ration.

Barley, owing to its misuse in the past, has a bad reputation as a poultry food. Nevertheless, properly screened to get rid of the awns, it may safely replace 25% of the grain ration, and in fattening mashes can form one-third of the total mash.

Rye is not liked by fowls, consequently there is difficulty in getting them to eat it at first. When educated to it, up to 40% of the grain ration can consist of rye. It may also form 20% of the mash of growers and layers, but should never be included in chick mashes, as it gives rise to sticky droppings which ball up on the feet of the chicks and so causes lameness and sometimes death.

Mash substitutes.

Grass meal and lucerne meal can be regarded as a substitute for grass or green food. It is normally included in chick, growers, and layers, rations up to 7% but in times of food shortage may be used at levels as high as 18%. In the latter case, no bran or middlings are included in the mash. Cereal substitutes to replace maize meal in the

ration can consist of ground wheat, ground dari, barley meal or ground oats, or mixtures of these materials. It is advisable to include lucerne meal as well to replace the vitamin A present in the maize meal but absent, or nearly absent, in the cereal substitutes. Boiled or steamed potatoes form a very effective substitute for cereal grains and should be replaced in the proportion of 4 lb. of potatoes for each pound of grain. Thus 32 lb. of boiled potatoes will replace 8 lb. of maize meal in a mash.

Green foods such as cabbage, thousand headed kale and marrow-stem kale will help to reduce mash consumption, but the amount of the saving is limited owing to the bulky character of the green food. Silage can also be incorporated in a mash in winter months, but the saving resulting from its use is doubtful. In any case, the silage must be finely chopped, and if more than 1 ounce per head per day is given to laying fowls, egg production is likely to be adversely affected. If possible, at least 10% of bran and 20% of weatings or middlings should be included in all mashes, since it is difficult to compound suitable mashes if wheat offals are reduced below these amounts. Substitutes which can be used as bran and middlings substitutes are palm kernel meal, coconut meal, brewers' grains dried sugar-beet pulp, malt culms and oatfeed. Up to 20% of coconut meal or palm kernel meal can be used, 15% of malt culms, 10% of dried brewers' grains or oatfeed, or 7% sugar-beet pulp.

As protein supplements to replace fish meal; bean meal, pea meal or earthnut meal, can be used. One third of the fish meal only should be replaced in chick mashes, but the whole of the fish meal can be replaced in growers' and layers' rations. For every 10 lb. of bean meal, pea meal or earthnut meal used 2 lb. of a mineral mixture consisting of 30 parts steamed bone flour, 20 parts ground chalk, whiting or limestone flour, and 20 parts common salt should be incorporated.

As a substitute for dried skimmed milk; dried buttermilk or dried whey can be used. Owing to its low protein content, if dried whey is used as a substitute, a protein supplement should be added as well. Extracted soya-bean meal is not likely to be available in wartime, it is, however, a good protein substitute for fish meal or meat meal if supplemented with the mineral mixture mentioned above for use with bean meal, etc. A mixture of soya-bean meal and dried whey makes a very good combination for inclusion in chick mashes.

Root crops other than potatoes, such as mangolds after Christmas, carrots, swedes, and sugar beet, form useful adjuncts to growers' and layers' mashes during the winter months, and should preferably

be fed in a raw state. Parsnips should be boiled and can then be fed in the manner and amount indicated for potatoes.

Tapioca or manioc meal can be included in a wet mash up to 10% in layers' mashes as a cereal substitute, but is not suitable for inclusion in a dry mash.

Variation in Composition of Bran, due to Wartime Conditions.

The remarks made on the constitution and nutritive value of bran made earlier in this book (p. 86) have to be considered in relation to the changes in milling practice brought about by the exigencies of war. In peace time the flour extraction varied from 50% to 70% of the wheat berry, and the wheat offals consisted of various grades of middlings or weatings and bran. These products were fairly standard in composition and the remarks given earlier in this book applied to these standard products. The stepping up of the flour extraction to 85% of the wheat berry resulted in the virtual extinction of the middlings product, and the production of two types of bran, called respectively fine bran and coarse bran. The variation in composition brought about by these changes in milling practice can be seen by comparing analyses of the different types of bran.

	Pre-war bran.	Fine bran.	Coarse bran.
Moisture	13·0	13·0	12·2
Ether extract	3·8	4·0	5·1
Crude protein	15·1	15·0	15·3
Soluble carbohydrates	52·8	55·6	52·6
Crude fibre	9·5	8·1	9·9
Ash	5·8	4·4	5·0
	100·0	100·0	100·0

It will be noted that the wartime fine bran is a better product than the pre-war bran, whereas the wartime coarse bran is not so good, although the differences are small. From the point of view of poultry feeding, the differences between the fine and coarse brans are larger than the chemical analyses would indicate, since 32·4 parts of the soluble carbohydrates of the fine bran consist of starch, whereas only 23·1 parts of the soluble carbohydrates of the coarse bran consist of starch. This difference was clearly brought out in a metabolizable energy determination, the fine bran yielding 2,059 large calories per kilogram of metabolizable energy, as compared

with 1,637 in the case of the coarse bran. In spite of these differences, the feeding value of the wartime brans had not been altered sufficiently to vitiate the general remarks on its value and uses given earlier in this book. Recently, however, the position has been materially changed owing to the dilution of wheat with barley and oats prior to milling for flour. The result of this change has been to introduce into the bran varying quantities of barley and oat offal, and in a recent sample analysed, approximately 17% of the bran consisted of coarse offal other than pure wheat bran. The fact that wartime bran is likely to contain barley and/or oat residues should therefore be borne in mind by stock feeders when using this feeding-stuff.

Wartime Developments in Poultry Feeding.

As envisaged in pages 333-335, the impact of war has severely restricted feeding-stuff supplies for poultry feeding. Broadly speaking, importation of feeding-stuffs specifically earmarked for animal feeding has stopped, the use for animal feeding of foods capable of use as human food or for manufacture into human food has been prohibited with very few exceptions, and the increased extraction of flour from the wheat berry has severely curtailed the amount of home-milled wheat offals available for animal feeding. In fact, middlings as such have practically disappeared, and the wheat feed available consists of two grades of bran, fine bran and coarse bran. On chemical analysis, the main differences between these two classes of bran are related to the fibre content and the N-free extract, the coarse bran containing nearly 2% more fibre and nearly 3% less N-free extract than the fine bran. The main difference affecting the feeding value of these brans for poultry resides in the starch content, there being 23·11% starch in the coarse bran as compared with 32·39% in the fine bran. As a result of this difference, fine bran is more suitable as a feeding-stuff for poultry than coarse bran; trials at Cambridge having shown that fine bran yields 936 large calories of metabolisable energy per lb. as compared with 735 large calories in the case of coarse bran.

The potential value of sunflower-seeds as a poultry feeding-stuff has also been investigated. It has been found that sunflower-seeds contain 15·19% digestible protein and 1403 large calories of metabolizable energy per lb. Comparable figures for Wilhelmina wheat are 8·41% digestible protein and 1360 large calories of metabolizable energy per lb. Sunflower-seeds can therefore be regarded as equal in feeding value to wheat so far as the available energy is concerned, and nearly double the value as a source of

protein. Palatability tests on eggs produced by fowls given sunflower-seeds as a grain food gave excellent results both from the point of view of flavour and quality. Consequently, the use of sunflower-seeds as a grain substitute can be safely recommended to poultry keepers.

Evidence has also been obtained on the desirability of cooking potatoes intended for use in poultry feeding. Tests at Cambridge have shown that, whereas raw minced potatoes yield per 100 lb. of potatoes 1·40 lb. digestible protein and 3·60 lb. digestible carbohydrates, 100 lb. of boiled potatoes yield 1·45 lb. digestible protein and 18·10 lb. of digestible carbohydrates. The need for cooking potatoes if they are intended for poultry feeding is therefore obvious. Since, under present conditions, "chat" potatoes or potatoes surplus to human food requirements are the only food commodity likely to be available in any quantity for poultry feeding, two rations successfully used at Wye, Kent, may with advantage be quoted. They are:

For Chick Rearing.

Boiled potatoes (peeled)	80 parts by weight
Weatings	20
Fish meal	3
Dried yeast	2
Cod liver oil	0·4
Limestone flour	0·5

For Egg Production.

Boiled potatoes (unpeeled)	80 parts by weight (lb.)
Weatings	20
Fish meal	3
Salt	3 oz.

Both rations were fed *ad lib.*, the chicks being reared in battery brooders, the layers in semi-intensive houses with grass runs. The layers also had access to limestone grit and flint grit. Similarly, Temperton and Dudley successfully reared pullets from the age of 8 weeks to maturity on a ration composed largely of steamed potatoes supplemented with alfalfa meal and meat meal in one case, and with meat meal only in another, both rations having a modicum of salt and cod-liver oil included. In the meat meal alfalfa meal group, the proportion of potatoes to mash was approximately 4½ to 1 by weight, in the case of the meat meal potato group the proportion was about 7½ to 1. The results of these experiments show that relatively large quantities of cooked potatoes can be incorporated in wartime poultry mashes and yield good results,

and indicate that up to half the total poultry ration calculated on a dry matter basis can consist in time of need of boiled potatoes (this means roughly 4 lb. of boiled potatoes to every lb. of rearing or laying mash), or even more in the case of growing stock over 8 weeks of age.

Use of Raw Green Vegetables or Silage in Poultry Feeding.

All experimental work carried out on the possibility of using green vegetables as a food substitute in poultry rations has shown that no substantial saving in poultry meal is likely to result. In fact, the attempt to include large quantities of minced green food or silage may lead to undesirable results. Thus at Wye, the inclusion of 30 parts of minced raw cabbage in the rations quoted above led to high mortality in the case of the chicks, and cessation of egg production and loss of body weight in the case of the laying stock. All the published work on this problem would indicate that green food in moderate amount may be of some value in the maintenance of the health of poultry and improvement of egg yolk colour, but that the use of green food in poultry rations is not likely to lead to any considerable saving in mash. This finding also applies to fresh-cut lawn grass, since Temperton and Dudley found that even when only 10% of the mash for growing stock was replaced by its equivalent in grass, much of the latter was found in the droppings in an apparently little-altered condition, and there was a marked reduction in the growth rate of the chicks. In reporting this finding, the authors state that it is probable that drying the grass and grinding it into a meal would increase its digestibility and make it a more useful food for poultry.

Feeding in Wartime by Domestic Poultry Keepers.

The scarcity of eggs brought about by war conditions has considerably increased the number of fowls kept by backyarders or Domestic Poultry Keepers, and it has been estimated that nearly 15,000,000 fowls are now being kept by this class of poultry keeper. The feeding problems created by this class of poultry keeper have been studied, principally at Cambridge. Such poultry keepers are expected to keep their fowls mainly on the edible household waste, supplemented by a small amount of purchased 'balancer meal.' The allowance of 'balancer meal' provided at the time of writing is 1 lb. per fowl per week, or approximately 2·3 oz. a head per day. The results of a daily collection of household waste from a number of small households consisting of 2 to 3 adults, 1 to 2 children, with an occasional domestic pet such as a dog or cat were as follows, spread over a full year's collection :

Daily Amounts of Edible Waste.

Period	Weight of scraps	Dry weight equivalent
Mid-Jan.—April	1·22 lb.	4·18 oz.
Mid-April—mid-July	0·85 lb.	3·42 oz.
Mid-July—mid-Oct.	1·34 lb.	4·89 oz.
Mid-Oct.—mid-Jan.	1·14 lb.	4·11 oz.

Distribution of Edible Waste in Classes.

	Fresh weight	Dry weight equivalent
Bread class	8·45%	23·26%
Green vegetable class	21·27%	11·91%
Vegetable-peeling class	67·67%	57·30%
Meat class	2·61%	7·53%

It is apparent from these figures that the average edible waste from typical small households amounts to an average of approximately 1 lb. per day of fresh waste, or on a dry matter basis, about 4 oz.

It is also apparent from the dry weight figures that approximately 80% of the edible waste is derived from stale bread and vegetable peelings derived from potatoes and root vegetables. It should be noted that the bread waste was only 1·35 oz. a day per household or 10 oz. a week. A comparison of the chemical composition of this edible waste on a 10% dry matter basis, with that of a pre-war all-mash diet gave the following figures :

	Edible household waste	Pre-war all-mash for egg production
Crude protein	12·77%	16·40%
Fat	9·15%	4·13%
Fibre	4·14%	5·51%
Soluble Carbohydrates ..	56·14%	56·55%
Ash	7·81%	3·49%

At first sight it would appear that in order to make edible household waste equivalent to a pre-war mash in egg-producing value, all that would be needed would be to add a protein concentrate such as fish meal or meat meal. This problem is not as simple as this, owing to the fact that the edible waste is so bulky that the fowl cannot eat enough within the limits of its appetite to provide all the necessary requirements for egg production. Accordingly the edible household waste must be supplemented by a protein cereal mash, and it was found that a bird allowed to feed *ad lib.* could consume daily from 6 to 8 oz. of edible waste in addition to 2 oz. of a protein-cereal mash, thus providing it with 4 oz. a day of dry matter calculated to provide for satisfactory egg production. It will be noted that the ' balancer meal ' allowance provided for this

class of poultry keeper is in accordance with this finding; it is equally obvious on this basis that the average small household can only supply enough edible waste to provide for two fowls. Attempts to keep more than this number of birds per household will obviously involve undue wastage of edible food unless the householder takes steps to collect the edible waste of his neighbours, or purchases the processed edible waste now being produced by many Local Authorities and others.

APPENDIX

TABLE I

COMPOSITION AND NUTRITIVE VALUE OF FEEDING-STUFFS*

(For use with dairy cows, cattle and sheep)

	Average Composition per cent. as shown by analysis						Digestible nutrients per cent.				Calculated from digestible nutrients		
				Carbo-hydrates					Carbo-hydrates			Per 100 lb.	
	Dry Matter	Protein	Oil	Soluble	Fibre	Ash	Protein Equivalent	Oil	Soluble	Fibre	*Nutritive Ratio	V	Starch Equivalent
SUCCULENTS—													
Roots													
Artichoke	20·4	1·5	0·2	16·9	0·7	1·1	0·7	—	15·8	0·2	23	92	16·4
Carrots	13·0	1·2	0·2	9·3	1·4	0·9	0·6	0·1	8·9	0·7	16	87	8·8
Kohl-Rabi	12·7	2·0	0·1	8·2	1·4	1·0	0·5	—	7·4	0·6	16	90	8·3
Mangolds	12·2	1·0	0·1	9·5	0·8	0·8	0·4	—	8·7	0·4	23	70	6·3
Potatoes	23·8	2·1	0·1	19·7	0·9	1·0	0·8	—	17·7	—	22	100	18·5
Sugar Beet	23·4	1·1	0·1	20·4	1·1	0·7	0·6	—	19·3	0·4	33	75	15·0
Swede-Turnip ..	11·5	1·3	0·2	8·1	1·2	0·7	0·7	—	7·5	0·8	12	85	7·3
Turnip	8·5	1·0	0·2	5·7	0·9	0·7	0·4	—	5·2	0·3	13	77	4·4
Miscellaneous													
Brewers' Grains(fresh)	32·4	7·5	2·8	14·6	6·1	1·4	5·4	2·4	9·1	2·4	3	86	18·4
Distillers' ,, ,,	26·2	8·4	3·0	10·4	3·6	0·8	6·0	2·6	6·4	1·7	2	86	16·2
Sugar-beet Pulp ,,	15·0	1·6	0·1	9·6	3·1	0·6	1·0	—	8·7	2·8	12	94	11·7
Green Foods													
Sugar-beet tops ..	16·2	2·0	0·5	8·7	1·6	3·4	1·2	0·3	7·2	1·1	7	84	8·6
Cabbage, drumhead	11·0	1·5	0·4	5·9	2·0	1·2	0·9	0·2	4·6	1·4	7	94	6·6
,, open-leaved	15·3	2·5	0·7	8·1	2·4	1·6	1·5	0·4	6·5	1·7	6	94	9·5
Carrot tops	16·0	2·1	0·6	8·0	2·9	2·4	1·2	—	6·8	2·1	6	100	10·0
Kale, Thousand-head	15·8	2·2	0·4	8·4	3·1	1·7	1·4	0·2	7·5	1·8	7	92	10·3
,, Marrow stem													
,, (unthinned) ..	14·0	2·2	0·5	6·9	2·5	1·9	1·4	0·3	6·1	1·6	6	93	9·1
,, (singled-out) ..	13·9	2·1	0·3	7·2	2·5	1·8	1·3	0·2	6·4	1·5	6	93	9·0
Maize	19·4	1·7	0·5	10·4	5·6	1·2	0·8	0·3	6·7	3·1	10	83	9·1
Mustard	14·9	2·9	0·4	7·3	2·9	1·4	1·6	0·2	4·9	1·5	4	90	7·2
Rape	14·1	2·8	0·8	5·7	3·5	1·3	1·6	0·5	3·9	1·9	4	87	6·9
Rye	23·4	3·0	0·9	10·3	7·5	1·7	1·8	0·5	7·0	4·9	7	—	11·4
Grasses													
Pasture Grass, close-grazing :											1 :		
Non-Rotational ..	20·0	5·3	1·1	8·9	2·6	2·1	4·2	0·7	7·8	2·1	3		14·1
Rotational, 3 wkly. intervals*	20·0	4·5	1·3	9·3	3·1	1·8	3·4	0·8	8·0	2·5	4		14·2
,, monthly ,,*	20·0	3·5	1·0	9·2	4·5	1·8	2·4	0·5	7·6	3·7	5		13·1
Pasture Grass, extensive grazing :													
Spring value, running off during Summer ..	20·0	3·5	0·8	9·7	4·0	2·0	2·1	0·4	7·3	2·6	5		11·1
Winter pasturage (after close grazing allowing free growth from end July-Dec.) ..	20·0	3·1	0·6	10·3	4·4	1·6	1·8	0·2	7·9	2·6	7		11·0

Data for fore-flush should be taken as for non-rotational close grazing.

* Based on similar tables published in the Ministry of Agriculture's Bulletin No. 48, and here reproduced by permission of the Controller, H.M. Stationery Office.

COMPOSITION AND NUTRITIVE VALUE OF FEEDING-STUFFS—continued

(For use with dairy cows, cattle and sheep)

	Average Composition per cent. as shown by analysis						Digestible nutrients per cent.				Calculated from digestible nutrients		
				Carbohydrates					Carbohydrates			Per 100 lbs.	
	Dry Matter	Protein	Oil	Soluble	Fibre	Ash	Protein Equivalent	Oil	Soluble	Fibre	Nutritive Ratio	V	Starch Equivalent
Grasses													
Rye Grass, perennial	24·8	2·9	0·7	11·5	7·1	2·6	1·6	0·3	7·4	4·0	8		10·7
„ Italian ..	25·0	3·4	1·0	11·6	6·2	2·8	1·7	0·5	7·7	3·6	7		11·4
Timothy	33·1	3·1	1·0	17·6	9·2	2·2	1·3	0·5	11·1	4·8	13		14·1
Green Legumes													
Alsike	15·0	3·3	0·6	5·1	4·5	1·5	1·8	0·4	3·6	2·2	4		6·6
Crimson Clover ..	18·5	2·8	0·7	6·9	6·2	1·9	1·8	0·5	5·2	3·5	6		9·0
Red Clover, beginning to flower	19·0	3·4	0·7	8·1	5·2	1·6	2·1	0·5	6·3	3·0	5		10·3
Trifolium (see Crimson Clover)													
White Clover, beginning to flower ..	18·5	4·4	0·8	6·9	4·3	2·1	2·4	0·5	4·7	2·6	4		8·8
Beans, beginning to flower	15·0	3·2	0·8	5·7	3·3	2·0	1·9	0·5	4·1	1·6	4		7·1
Kidney Vetch ..	18·0	2·4	0·6	8·6	5·1	1·3	1·0	0·3	5·7	2·7	9		8·0
Lucerne—													
(in early flower)	24·0	4·1	0·4	9·9	7·2	2·4	2·6	0·1	6·6	3·2	4		9·3
(in bud) ..	22·0	4·5	0·5	9·0	6·2	1·8	3·0	0·1	6·8	3·1	3		10·3
(before bud) ..	15·0	3·8	0·4	5·7	3·3	1·8	2·6	0·1	4·6	2·1	3		7·9
Peas, beginning to flower	16·8	3·5	0·6	5·6	5·9	1·2	2·0	0·3	3·7	3·0	4		6·8
Sainfoin, in flower ..	20·0	3·5	0·6	7·8	6·9	1·2	2·0	0·3	4·8	3·2	4		7·6
Tares, in flower ..	17·5	3·2	0·5	7·2	5·1	1·5	1·8	0·3	4·9	2·3	4		7·5
Trefoil	20·0	3·5	0·8	8·4	5·7	1·6	2·0	0·4	5·9	2·8	5		9·0
Vetches (see Tares)													
												V	Starch Equivalent
Silage													
Clover (Red) ..	21·7	4·4	1·2	7·1	6·5	2·5	2·3	0·6	5·1	3·5	4	81	9·2
Grass	19·4	2·0	0·8	8·1	6·5	2·0	1·2	0·4	4·7	3·8	8	78	7·9
Lucerne	16·9	3·7	1·4	4·7	5·0	2·1	2·0	0·7	3·3	2·1	4	81	6·6
Maize, Jaune Gros, English grown ..	21·0	2·3	1·2	11·3	4·9	1·3	1·0	1·1	7·9	3·4	14	82	12·1
Pea haulms and pods	25·6	3·6	0·6	12·0	6·8	2·6	2·0	0·3	8·1	3·4	6	82	11·0
Pea pods, from canning industry..	21·5	2·9	0·4	11·8	5·3	1·1	—	—	—	—	—	—	—
Sugar-beet tops ..	23·0	2·4	0·7	9·1	3·4	7·4	0·8	0·3	7·2	2·5	13	91	9·5
Vetch and oats—													
green fruity ..	27·3	3·4	1·2	12·5	8·0	2·2	1·7	0·9	8·7	4·6	9	76	12·8
acid brown ..	34·6	5·6	1·5	12·9	11·4	3·2	2·8	1·2	6·4	5·5	5	76	13·0

COMPOSITION AND NUTRITIVE VALUE OF FEEDING-STUFFS—continued

(For use with dairy cows, cattle and sheep)

	Average Composition per cent. as shown by analysis						Digestible nutrients per cent.				Calculated from digestible nutrients		
				Carbo-hydrates					Carbo-hydrates			Starch Eqv. Per 100 lb.	
	Dry Matter	Protein	Oil	Soluble	Fibre	Ash	Protein Equivalent	Oil	Soluble	Fibre	Nutritive Ratio	Fed long	Fed chaffed
ROUGHAGES—													
Hay													
Clover, Red, good average	83·5	13·5	2·9	37·1	24·0	6·0	7·0	1·7	26·0	11·3	6	31·7	38·7
Lucerne—													
before flowering	84·0	16·2	2·4	31·1	27·0	7·3	10·1	1·1	21·1	11·3	4	27·6	35·4
in full flower ..	83·5	14·2	2·6	29·2	29·5	8·0	8·0	1·2	18·1	13·2	4	22·4	30·9
in half flower (v. good quality)	84·0	18·9	1·1	30·6	25·4	8·0	11·8	—	20·4	12·2	3	27·1	34·5
Meadow Hay—													
poor	85·7	7·5	1·5	38·2	33·5	5·0	3·0	0·5	19·3	15·6	12	18·8	28·5
good average ..	85·7	9·7	2·5	41·0	26·3	6·2	4·6	1·0	25·7	15·0	9	31·0	38·6
very good ..	84·0	13·5	3·0	40·5	19·3	7·7	7·8	1·5	30·1	12·7	6	40·6	46·2
Rye Grass—													
perennial ..	86·0	10·4	2·6	41·1	25·4	6·5	5·8	1·1	26·3	13·2	7	31·7	39·1
Italian	86·0	11·2	3·5	41·6	22·1	7·6	6·2	1·7	27·9	12·8	7	36·3	42·8
Sainfoin in flower ..	83·5	13·2	2·5	32·5	28·0	7·3	8·6	1·6	25·3	11·8	5	31·0	39·2
Tares in full flower..	83·3	14·2	2·5	32·8	25·5	8·3	8·0	1·5	19·7	12·8	4	26·8	34·2
Tares and Oats (Tares in flower) ..	84·0	11·6	3·3	36·3	24·2	8·6	5·4	1·7	23·3	12·3	7	28·8	35·8
Vetches (see Tares)													
Seeds Hay (Rye Grass and Clover) ..	86·0	12·0	2·8	37·4	27·5	6·3	4·9	1·2	22·0	13·2	8	25·0	32·9
Straws													
Barley Straw, Spring	86·0	3·3	1·8	42·4	33·9	4·6	0·7	0·6	22·5	18·3	60	22·9	32·7
Bean Straw (including pods)	86·0	4·5	0·8	33·0	43·1	4·6	1·8	0·5	22·0	18·7	23	17·9	30·4
Oat Straw, average..	86·0	3·8	1·9	43·1	30·6	6·6	0·7	0·6	19·6	19·0	57	22·6	31·4
Pea, haulm ..	86·0	9·2	1·6	36·0	33·4	5·8	3·6	0·7	19·8	12·9	10	17·1	—
Rape	84·0	2·5	1·2	38·7	37·8	3·8	1·2	0·5	20·4	14·0	27	14·1	—
Wheat—													
Straw	86·0	2·5	1·3	40·3	34·2	5·7	0·1	0·4	14·8	18·2	33	14·0	—
Cavings ..	86·0	3·8	1·8	39·8	32·0	8·6	1·1	0·6	17·9	15·4	31	26·2	—
Chaff (glumes)..	86·0	3·7	1·2	42·6	27·7	10·8	1·1	0·4	19·2	13·3	30	26·2	—

COMPOSITION AND NUTRITIVE VALUE OF FEEDING-STUFFS—continued

(For use with dairy cows, cattle and sheep)

	Average Composition per cent. as shown by analysis						Digestible nutrients per cent.				Calculated from digestible nutrients		
				Carbo-hydrates					Carbo-hydrates			per 100 lb.	
	Dry Matter	Protein	Oil	Soluble	Fibre	Ash	Protein Equivalent	Oil	Soluble	Fibre	Nutritive Ratio	V	Starch Equivalent
CONCENTRATES—													
Cereals													
Barley	85·1	10·0	1·5	66·5	4·5	2·6	7·3	1·2	60·9	2·5	9	98	71·4
Dari	88·9	9·6	3·8	71·2	1·9	2·4	7·2	3·0	60·5	1·0	9	100	74·1
Maize	87·0	9·9	4·4	69·2	2·2	1·3	7·6	2·7	63·7	0·8	9	100	77·6
Oats	86·7	10·3	4·8	58·2	10·3	3·1	7·6	4·0	44·8	2·6	7	95	59·5
Rye	86·6	11·5	1·7	69·5	1·9	2·0	9·2	1·1	63·9	1·0	9	95	71·6
Wheat	86·6	12·1	1·9	69·0	1·9	1·7	9·6	1·2	63·5	0·9	7	95	71·6
Legumes													
Beans	85·7	25·4	1·5	48 5	7·1	3·2	19·7	1·2	44·1	4·1	3	97	65·8
Peas	86·0	22·5	1·6	53·7	5·4	2·8	18·2	1·0	49·9	2·5	3	98	69·0
Oil Seeds ..													
Beach Mast.. ..	88·9	13·3	27·4	25·5	18·5	4·2	10·4	24·1	16·8	7·4	8	94	86·2
Hemp Seed ..	91·1	18·2	32·6	21·1	15·0	4·2	13·2	29·3	16·8	9·0	7	96	103·7
Linseed	92·9	24·2	36·5	22·9	5·5	3·8	18·8	34·7	18·3	1·8	5	99	119·2
Soya Bean	90·0	33·2	17·5	30·5	4·1	4·7	27·8	15·8	20·8	1·7	2	98	78·9
Sunflower Seed ..	92·5	14·2	32·3	14·5	28·1	3·4	12·0	30·7	10·3	9·4	7	92	103·8
Miscellaneous Seeds													
Acorns, fresh ..	50·0	3·3	2·4	36·3	6·8	1·2	2·4	1·9	32·6	4·1	17	95	41·2
Buckwheat	85·9	11·3	2·6	54·8	14·4	2·8	8·0	1·9	42·3	3·5	6	93	53·4
Locust Beans ..	85·0	5·8	1·3	69·0	6·4	2·5	3·6	0·7	65·5	3·7	20	97	71·4
Oil Cakes and Meals													
Coconut—													
Cake	88·6	21·2	8·0	42·4	11·5	5·5	16·4	7·8	35·1	7·3	4	100	76·8
Meal	88·7	19·5	6·7	42·5	13·6	6·4	15·1	6·5	35·4	8·6	4	100	73·6
Cotton Cake—													
Bombay	87·7	20·2	4·8	35·2	21·7	5·8	15·2	4·5	18·9	4·4	2	84	40·0
Brazilian	89·0	27·1	5·4	27·1	24·9	4·5	20·2	5·0	14·7	5·2	2	84	42·0
Egyptian	87·9	23·2	5·0	32·6	21·3	5·8	17·3	4·6	17·7	4·5	2	84	41·6
decorticated ..	90·2	41·2	8·0	26·5	7·8	6·7	34·6	7·5	17·7	2·2	1	97	68·4
Cotton Seed Meal ..	91·3	43·6	8·0	25·8	7·7	6·2	36·8	7·6	17·4	2·1	1	97	70·1
Ground-nut Cake—													
decorticated ..	89·7	46·8	7·5	23·2	6·4	5·8	41·3	6·8	19·7	0·5	1	98	73·0
undecorticated ..	89·7	30·2	9·1	21·8	22·9	5·7	27·2	8·2	18·4	2·6	1	86	56·8
Ground-nut Meal—													
undecort. extracted	92·4	31·8	1·9	29·1	25·3	4·3	28·7	1·5	20·0	2·9	1	84	44·4
Linseed Cake—													
English made ..	88·8	29·5	9·5	35·5	9·1	5·2	24·6	8·7	28·5	4·5	2	97	74·0
foreign	89·0	32·3	9·9	32·2	8·7	5·9	27·0	9·1	25·8	4·3	2	97	74·5

COMPOSITION AND NUTRITIVE VALUE OF FEEDING-STUFFS—continued

(For use with dairy cows, cattle and sheep)

	Average Composition per cent. as shown by analysis						Digestible nutrients per cent.				Calculated from digestible nutrients		
				Carbo-hydrates					Carbo-hydrates			Per 100 lb.	
	Dry Matter	Protein	Oil	Soluble	Fibre	Ash	Protein Equivalent	Oil	Soluble	Fibre	1 : Nutritive Ratio	V	Starch Equivalent
Oil Cakes and Meals													
Linseed Meal— extracted	88·2	35·7	3·1	33·9	9·0	6·5	30·4	2·8	27·2	4·5	1	96	63·7
Maize Germ Meal ..	89·2	13·0	12·5	56·0	4·1	3·6	10·3	11·5	47·0	2·5	7	97	84·3
Maize, flaked ..	89·0	9·8	4·3	72·5	1·5	0·9	9·2	2·0	70·4	0·5	8	100	84·0
Palm Nut Kernel Cake—													
English made ..	89·0	19·2	6·0	46·5	13·4	3·9	17·0	5·3	39·4	5·1	3	100	73·2
imported ..	90·3	16·6	10·2	38·2	21·3	4·0	13·9	9·8	32·6	12·8	5	100	81·7
Palm Nut Kernel Meal—extracted	90·0	19·0	2·0	49·0	16·0	4·0	16·6	1·9	43·5	8·0	3	100	71·3
Soya-Bean—													
Cake	85·5	43·1	5·6	26·3	5·1	5·4	36·9	5·1	20·4	3·7	1	97	68·9
Meal, extracted ..	88·7	44·7	1·5	31·9	5·1	5·5	38·3	1·4	24·7	3·6	1	97	64·0
By-Products													
Barley—													
Brewers' Grains, fresh	32·4	7·5	2·8	14·6	6·1	1·4	5·4	2·4	9·1	2·4	3	86	18·4
dried	89·7	18·3	6·4	45·9	15·2	3·9	12·6	5·6	27·6	7·3	4	84	48·3
Distillers' Grains, fresh	26·2	8·4	3·0	10·4	3·6	0·8	6·0	2·6	6·4	1·7	2	86	16·2
dried	92·0	27·7	11·6	40·8	10·1	1·8	19·2	10·2	25·3	4·8	3	84	57·2
Malt Coombs ..	90·0	24·4	2·0	42·4	14·0	7·2	16·0	1·5	30·9	12·7	3	75	43·4
Blood Meal ..	86·0	81·0	0·8	1·5	—	2·7	68·2	0·8	—	—	—	100	62·9
Fish Meal, White ..	87·0	61·0	3·5	1·5	—	21·0	53·0	3·3	1·2	—	—	100	58·9
Herring Meal ..	86·3	63·5	8·3	4·2	—	10·2	57·1	7·6	3·4	—	—	100	75·1
Lucerne Meal, English (from crop just coming into flower bud)	91·0	22·3	2·9	36·4	18·0	11·4	13·6	1·3	28·4	9·5	3	91	50·1
Lucerne Meal, English (from crop in early flower)	91·0	16·2	2·4	37·7	24·5	10·2	10·4	0·7	27·8	11·2	4	86	44·1
Lucerne Leaf Meal— American ..	91·0	21·4	1·9	40·6	16·0	11·1	15·5	—	31·5	7·9	2	92	50·2
Maize Gluten—													
feed	89·6	23·5	3·4	56·7	3·5	2·5	19·2	2·7	49·3	2·5	3	100	75·6
meal	90·9	35·5	4·7	47·5	2·1	1·1	30·4	4·4	42·6	—	2	100	81·5
Meat and Bone Meal	90·3	50·3	15·0	1·0	—	24·0	34·2	14·3	—	—	1	100	67·8
(low fat) ..	93·0	66·7	2·9	4·0	—	19·4	51·0	2·4	3·9	—	—	100	59·6
Pure Meat Meal ..	89·2	72·2	13·2	—	—	3·8	65·4	12·5	—	—	—	100	91·0

COMPOSITION AND NUTRITIVE VALUE OF FEEDING-STUFFS—continued

(For use with dairy cows, cattle and sheep)

	Average Composition per cent. as shown by analysis						Digestible nutrients per cent.				Calculated from digestible nutrients		
				Carbo-hydrates					Carbo-hydrates			Per 100 lb.	
	Dry Matter	Protein	Oil	Soluble	Fibre	Ash	Protein Equivalent	Oil	Soluble	Fibre	Nutritive Ratio	V	Starch Equivalent
By-Products													
Commercial Meat Meal	90·5	60·0	11·0	0·5	—	19·0	42·0	10·5	—	—	0·6	100	66·0
Milk—													
buttermilk ..	9·2	3·6	0·8	4·1	—	0·7	3·4	0·8	4·1	—	2	100	9·2
cow's, whole ..	12·8	3·4	3·9	4·8	—	0·7	3·2	3·9	4·8	—	4	100	17·1
separated ..	9·4	3·5	0·1	5·0	—	0·8	3·3	0·1	5·0	—	2	100	8·3
skimmed—													
deep set ..	9·7	3·5	0·4	5·0	—	0·8	3·3	0·4	5·0	—	2	100	9·1
shallow set ..	10·0	3·5	0·7	5·0	—	0·8	3·3	0·7	5·0	—	2	100	9·8
whey	6·6	0·7	0·2	5·0	—	0·7	0·6	0·2	5·0	—	9	100	6·1
Dried—													
whole milk ..	95·8	25·5	26·5	37·4	—	6·4	24·0	26·5	37·4	—	4	100	123·1
separated milk ..	89·8	32·8	0·3	48·8	—	7·9	30·9	0·3	48·8	—	2	100	78·7
buttermilk ..	90·0	42·3	11·2	24·3	—	12·2	40·0	11·2	24·3	—	2	100	89·2
whey	92·8	13·6	3·0	68·4	—	7·8	11·7	3·0	68·4	—	9	100	86·7
Potato—													
cossettes	89·5	8·7	0·5	74·6	2·1	3·6	4·8	—	64·4	—	13	100	68·9
flakes	89·6	8·2	0·3	75·2	2·1	3·8	3·7	—	70·4	—	19	100	73·9
slices	89·5	9·4	0·2	74·4	1·6	3·9	4·1	—	69·0	—	17	100	72·9
Rice Meal or Pollard	91·1	12·9	13·7	49·5	6·4	8·6	7·1	11·6	39·0	1·6	10	100	72·3
True Rice Meal ..	89·1	8·0	2·0	66·6	8·0	4·5	—	—	—	—	—	—	—
Sago Pith Meal ..	87·0	1·7	0·4	77·2	4·3	3·4	0·8	—	66·2	—	86	98	66·9
Sugar-beet Pulp—													
wet	15·0	1·6	0·1	9·6	3·1	0·6	1·0	—	8·7	2·8	12	94	11·7
dried	90·0	8·9	0·6	59·1	18·3	3·1	5·2	—	54·0	16·3	14	77	60·6
molassed ..	90·0	10·8	0·4	58·2	15·1	5·5	4·6	—	53·0	13·5	14	77	58·3
Sugar-beet Molasses	74·7	3·5	—	66·0	—	5·2	1·2	—	59·2	—	—	87	51·6
Tapioca Flour ..	88·0	1·8	0·5	81·1	2·5	2·1	1·2	0·1	80·3	1·9	69	100	83·5
Concentrated Urban Swill "Tottenham pudding"	29·7	3·9	2·3	17·6	1·5	4·4	2·4	1·9	15·8	0·7	9	100	23·4
Whale Meat—													
Flakes	88·0	60·0	12·0	—	—	16·0	—	—	—	—	—	—	—
Meal	92·0	60·0	16·0	—	—	16·0	—	—	—	—	—	—	—
Yeast, dried	95·7	48·5	0·5	35·5	0·5	10·7	40·7	0·2	29·2	—	1	100	67·2
Wheat-Germ Meal (vacuum heated)	89·8	32·0	9·2	41·9	2·0	4·7	—	—	—	—	—	—	—
Wheat Offals													
Fine Middlings ..	86·7	8·4	2·3	72·3	1·9	1·8	7·4	2·1	70·1	0·7	10	—	81·7
Coarse Middlings ..	87·0	16·4	4·4	56·4	6·1	3·7	13·1	3·4	48·1	2·1	4	—	68·1
Bran	87·0	15·1	3·8	52·8	9·5	5·8	11·8	3·3	40·7	3·5	4	—	59·6
Broad Bran	87·0	14·7	4·0	52·1	10·3	5·9	11·4	3·5	39·2	3·9	4	—	58·4
Weatings	85·8	15·6	3·8	57·9	5·2	3·3	12·6	2·9	50·2	1·8	5	—	68·6
Superfine Weatings	86·6	15·9	3·5	60·7	3·7	2·8	13·0	2·7	54·8	1·3	5	—	73·1

TABLE II
MINERAL CONTENT OF SOME COMMON FEEDING-STUFFS*

	Total Ash per cent.	Lime (CaO) per cent.	Phosphoric Acid (P_2O_5) per cent.	Potash (K_2O) per cent.	Chlorine (Cl_2) per cent.
Mangolds	0·9	0·02	0·09	0·45	0·16
Potatoes	1·0	0·03	0·18	0·60	0·04
Swedes	0·7	0·08	0·08	0·30	0·04
Cabbage	1·2	0·20	0·15	0·40	0·02
Kale, thousand head	1·7	0·39	0·13	0·52	0·16
„ marrow stem	1·9	0·43	0·12	0·55	0·21
Sugar-beet tops	3·4	0·34	0·11	0·58	—
Pasture Grass (rotational close-grazing)	2·0	0·28	0·16	0·60	0·19
Vetches, in flower	1·5	0·50	0·15	0·50	—
Clover, red, flowering	1·6	0·40	0·15	0·50	0·05
Lucerne (before bud)	1·8	0·45	0·13	0·48	0·05
„ (in bud)	1·8	0·77	0·14	0·56	0·05
„ (early flower)	2·4	0·96	0·12	0·43	0·08
Meadow Hay, good	6·2	1·00	0·43	1·60	0·37
Red Clover Hay	7·0	1·60	0·39	2·20	0·24
Seeds Hay	6·3	2·00	0·60	1·80	0·30
Lucerne Hay (half flower) ..	8·0	2·74	0·51	1·52	0·34
Oat Straw	4·9	0·36	0·18	1·50	0·30
Wheat Straw	5·3	0·29	0·13	0·80	0·20
Bean Straw, including pods ..	4·6	1·20	0·30	1·90	—
Pea Straw	6·6	1·60	0·40	1·00	—
Barley	2·6	0·07	0·84	0·57	0·12
Maize	1·3	0·02	0·82	0·40	0·07
Oats	3·1	0·14	0·81	0·55	0·07
Wheat	1·7	0·05	0·86	0·60	0·08
Beans	3·2	0·18	0·88	1·28	0·03
Peas	2·8	0·10	0·90	1·00	0·04
Bran	5·8	0·20	2·80	1·50	0·09
Weatings	3·6	0·10	2·60	1·40	0·03
Superfine Weatings	3·1	—	—	—	—
Coconut Cake	5·4	0·50	1·50	2·00	0·64
Cotton Cake, undecorticated ..	5·8	0·30	2·50	1·60	0·05
Cotton Seed Meal	6·0	0·36	2·70	1·60	0·04
Ground-nut Cake, dec. ..	5·8	0·20	1·30	1·50	0·03
„ „ „ undec. ..	5·7	0·20	1·00	1·10	—
Linseed Cake	5·2	0·51	1·70	1·30	0·09
Palm Kernel Cake	3·8	0·30	1·10	0·50	0·16
Soya-bean Cake	5·3	0·30	2·00	1·80	0·03
Soya-bean Meal, extr. ..	5·5	0·30	2·10	1·90	0·03
Fish Meal, white	21·6	10·00	9·00	1·20	1·00
Herring Meal	10·2	—	2·45	—	—
Meat Meal, pure	3·8	0·40	0·70	0·10	0·27
„ „ commercial ..	19·0	10·00	8·30	—	0·40
Meat and Bone Meal	24·0	11·50	10·30	—	0·70
Blood Meal	2·7	0·05	0·22	0·31	0·85
Yeast, dried	10·7	0·30	5·50	2·00	0·03

* Reproduced from the Ministry of Agriculture's Bulletin No. 48, by permission of the Controller, H.M. Stationery Office.

MINERAL CONTENT OF SOME COMMON FEEDING-STUFFS—continued

	Total Ash per cent.	Lime (CaO) per cent.	Phosphoric Acid (P_2O_5) per cent.	Potash (K_2O) per cent.	Chlorine (Cl_2) per cent.
Milk, whole	0·8	0·17	0·20	0·20	0·10
„ separated	0·8	0·15	0·20	0·20	0·10
Whey	0·7	0·10	0·10	0·15	0·07
Brewers' Grains, dried.. ..	3·9	0·40	1·60	0·20	0·06
Distillers' „ „ ..	1·8	0·40	0·68	0·20	0·06
Locust Bean Meal	4·0	0·85	0·26	0·70	—
Maize Meal, degermed ..	0·9	0·02	0·39	0·33	0·03
Maize, flaked	0·9	Trace	0·60	0·25	Trace
Maize Germ Meal	3·6	0·10	0·90	1·30	—
„ Gluten Meal	1·1	0·05	0·30	0·05	0·01
„ „ Feed ..	2·5	0·10	0·70	0·20	0·04
Rice Meal, Pollard	8·6	0·10	2·50	0·70	0·14
Sago Pith Meal	3·4	0·33	0·11	0·54	0·56
Sugar-beet pulp, dried ..	3·1	1·20	0·18	0·59	0·05
„ „ molassed ..	5·5	1·20	0·17	1·34	0·48
Tapioca Flour	2·2	0·22	0·25	1·04	0·02
Steamed Bone Flour (dry matter)	88·7	45·8	31·1	—	—

TABLE III

RATION READY RECKONER. A. SUCCULENTS AND FODDERS*

lb.	Dry Matter (lb.)	Starch Equivalent (lb.)	Protein Equivalent (lb.)	lb.	Dry Matter (lb.)	Starch Equivalent (lb.)	Protein Equivalent (lb.)	lb.	Dry Matter (lb.)	Starch Equivalent (lb.)	Protein Equivalent (lb.)
Carrots				Kohl Rabi				Mangolds			
10	1·30	0·88	0·06	10	1·27	0·83	0·05	10	1·22	0·63	0·04
25	3·25	2·20	0·15	25	3·18	2·08	0·12	25	3·05	1·58	0·10
28	3·64	2·46	0·17	28	3·56	2·32	0·14	28	3·42	1·76	0·11
40	5·20	3·52	0·24	40	5·08	3·32	0·20	40	4·88	2·52	0·16
56	7·28	4·93	0·34	56	7·11	4·65	0·28	56	6·83	3·53	0·22
Wet Beet Pulp				Potatoes				Swedes			
10	1·50	1·17	0·10	10	2·38	1·85	0·08	10	1·15	0·73	0·07
15	2·25	1·75	0·15	12	2·86	2·22	0·10	25	2·88	1·83	0·17
25	3·75	2·93	0·25	15	3·57	2·78	0·12	28	3·22	2·04	0·20
28	4·20	3·28	0·28	20	4·76	3·70	0·16	40	4·60	2·92	0·28
40	6·00	4·68	0·40	25	5·95	4·63	0·20	56	6·44	4·09	0·39
Turnips				Cabbage (drumhead)				Cabbage (open leaved)			
10	0·85	0·44	0·04	10	1·10	0·66	0·09	10	1·53	0·95	0·15
25	2·12	1·10	0·10	25	2·75	1·65	0·23	25	3·83	2·38	0·38
28	2·38	1·23	0·11	28	3·08	1·85	0·25	28	4·28	2·66	0·42
40	3·40	1·76	0·16	40	4·40	2·64	0·36	40	6·12	3·80	0·60
56	4·76	2·46	0·22	56	6·16	3·70	0·50	56	8·57	5·32	0·84
Clover (green)				Kale (thousand head)				Kale (marrow stem)			
10	1·90	1·03	0·21	10	1·58	1·03	0·14	10	1·40	0·91	0·14
15	2·85	1·54	0·31	25	3·95	2·58	0·35	15	2·10	1·36	0·21
20	3·80	2·06	0·42	28	4·42	2·88	0·39	25	2·80	1·82	0·28
30	5·70	3·09	0·63	40	6·32	4·12	0·56	30	4·20	2·73	0·42
40	7·60	4·12	0·84	56	8·85	5·77	0·78	40	5·60	3·64	0·56
Lucerne (in early flower)				Maize (green)				Pasture Grass (extensive grazing)			
10	2·40	0·93	0·26	10	1·94	0·91	0·08	20	4·00	2·22	0·42
20	4·80	1·86	0·52	15	2·91	1·36	0·12	30	6·00	3·33	0·63
25	6·00	2·32	0·65	20	3·88	1·82	0·16	40	8·00	4·44	0·84
30	7·20	2·79	0·78	30	5·82	2·73	0·24	50	10·00	5·55	1·05
40	9·60	3·72	1·04	40	7·76	3·64	0·32	70	14·00	7·77	1·47
Pasture Grass, non rotational (close grazing)				Silage (Grass)				Silage (Vetch and Oats)			
20	4·00	2·82	0·84	10	1·94	0·79	0·12	10	2·73	1·28	0·17
30	6·00	4·23	1·26	20	3·88	1·58	0·24	20	5·46	2·56	0·34
40	8·00	5·64	1·68	25	4·85	1·98	0·30	25	6·82	3·20	0·42
50	10·00	7·05	2·10	30	5·82	2·37	0·36	30	8·19	3·84	0·51
70	14·00	9·87	2·94	40	7·76	3·16	0·48	40	10·92	5·12	0·68

* Based on similar tables published in the Ministry of Agriculture's Bulletin No. 42, and here reproduced by permission of the Controller, H.M. Stationery Office.

RATION READY RECKONER—continued

Sugar-beet, tops and leaves

lb.	Dry Matter (lb.)	Starch Equivalent (lb.)	Protein Equivalent (lb.)
10	1·62	0·86	0·12
20	3·24	1·72	0·24
25	4·05	2·15	0·30
30	4·86	2·58	0·36
40	6·48	3·44	0·48

Vetches (green)

lb.	Dry Matter (lb.)	Starch Equivalent (lb.)	Protein Equivalent (lb.)
10	1·75	0·75	0·18
20	3·50	1·50	0·36
25	4·37	1·87	0·45
30	5·25	2·25	0·54
40	7·00	3·00	0·72

Brewers' Grains (wet)

lb.	Dry Matter (lb.)	Starch Equivalent (lb.)	Protein Equivalent (lb.)
10	3·24	1·84	0·54
12	3·89	2·21	0·65
15	4·86	2·76	0·81
20	6·48	3·68	1·08
25	8·10	4·60	1·35

Distillers' Grains (wet)

lb.	Dry Matter (lb.)	Starch Equivalent (lb.)	Protein Equivalent (lb.)
10	2·62	1·62	0·60
12	3·14	1·94	0·72
15	3·93	2·43	0·90
20	5·24	3·24	1·20
25	6·55	4·05	1·50

Hay (Clover)

lb.	Dry Matter (lb.)	Starch Equivalent (lb.) L.	Starch Equivalent (lb.) C.	Protein Equivalent (lb.)
7	5·84	2·21	2·71	0·49
10	8·35	3·17	3·87	0·70
12	10·02	3·80	4·64	0·84
14	11·69	4·44	5·42	0·98
21	17·54	6·66	8·13	1·47

Hay (Lucerne) ½ flower

lb.	Dry Matter (lb.)	Starch Equivalent (lb.) L.	Starch Equivalent (lb.) C.	Protein Equivalent (lb.)
7	5·84	1·90	2·42	0·83
10	8·40	2·71	3·45	1·18
12	10·08	3·25	4·14	1·42
14	11·76	3·79	4·83	1·65
21	17·64	5·69	7·24	2·48

Hay (Meadow) Poor

lb.	Dry Matter (lb.)	Starch Equivalent (lb.) L.	Starch Equivalent (lb.) C.	Protein Equivalent (lb.)
7	6·00	1·32	2·00	0·21
10	8·57	1·88	2·85	0·30
12	10·28	2·26	3·42	0·36
14	12·00	2·63	4·00	0·42
21	18·00	3·95	5·98	0·63

Hay (Meadow) Medium

lb.	Dry Matter (lb.)	Starch Equivalent (lb.) L.	Starch Equivalent (lb.) C.	Protein Equivalent (lb.)
7	6·00	2·17	2·70	0·32
10	8·57	3·10	3·86	0·46
12	10·28	3·72	4·63	0·55
14	12·00	4·34	5·40	0·64
21	18·00	6·51	8·11	0·97

Hay (Meadow) Very good

lb.	Dry Matter (lb.)	Starch Equivalent (lb.) L.	Starch Equivalent (lb.) C.	Protein Equivalent (lb.)
7	5·88	2·84	3·23	0·55
10	8·40	4·06	4·62	0·78
12	10·08	4·87	5·54	0·94
14	11·76	5·68	6·47	1·09
21	17·64	8·53	9·70	1·64

Hay (Seeds)

lb.	Dry Matter (lb.)	Starch Equivalent (lb.) L.	Starch Equivalent (lb.) C.	Protein Equivalent (lb.)
7	6·02	1·75	2·30	0·34
10	8·60	2·50	3·29	0·49
12	10·32	3·00	3·95	0·59
14	12·04	3·50	4·61	0·69
21	18·06	5·25	6·91	1·03

Straw (Barley)

lb.	Dry Matter (lb.)	Starch Equivalent (lb.) L.	Starch Equivalent (lb.) C.	Protein Equivalent (lb.)
7	6·02	1·60	2·29	0·05
10	8·60	2·29	3·27	0·07
12	10·32	2·75	3·92	0·08
14	12·04	3·21	4·58	0·10
21	18·06	4·81	6·87	0·15

Straw (Bean)

lb.	Dry Matter (lb.)	Starch Equivalent (lb.) L.	Starch Equivalent (lb.) C.	Protein Equivalent (lb.)
7	6·02	1·25	2·13	0·13
10	8·60	1·79	3·04	0·18
12	10·32	2·15	3·65	0·22
14	12·04	2·51	4·26	0·25
21	18·06	3·76	6·38	0·38

Straw (Oat)

lb.	Dry Matter (lb.)	Starch Equivalent (lb.) L.	Starch Equivalent (lb.) C.	Protein Equivalent (lb.)
7	6·02	1·58	2·20	0·05
10	8·60	2·26	3·14	0·07
12	10·32	2·71	3·77	0·08
14	12·04	3·16	4·40	0·10
21	18·06	4·75	6·59	0·15

Straw (Pea)

lb.	Dry Matter (lb.)	Starch Equivalent (lb.)	Protein Equivalent (lb.)
7	6·02	1·20	0·25
10	8·60	1·71	0·36
12	10·32	2·05	0·43
14	12·04	2·39	0·50
21	18·06	3·59	0·76

Straw (Wheat)

lb.	Dry Matter (lb.)	Starch Equivalent (lb.)	Protein Equivalent (lb.)
7	6·02	0·98	0·01
10	8·60	1·40	0·01
12	10·32	1·68	0·01
14	12·04	1·96	0·01
21	18·06	2·94	0·02

Wheat cavings

lb.	Dry Matter (lb.)	Starch Equivalent (lb.)	Protein Equivalent (lb.)
5	4·30	1·31	0·05
7	6·02	1·83	0·08
8	6·88	2·10	0·09
10	8·60	2·62	0·11
14	12·04	3·67	0·15

L. = fed long. C. = fed chaffed.

RATION READY RECKONER. B. CONCENTRATED FOODS

lb.	Dry Matter (lb.)	Starch Equivalent (lb.)	Protein Equivalent (lb.)	Dry Matter (lb.)	Starch Equivalent (lb.)	Protein Equivalent (lb.)	Dry Matter (lb.)	Starch Equivalent (lb.)	Protein Equivalent (lb.)	Dry Matter (lb.)	Starch Equivalent (lb.)	Protein Equivalent (lb.)
	Barley			Beans						Linseed		
1	0·85	0·71	0·07	0·86	0·66	0·20	–	–	–	0·93	1·19	0·19
2	1·70	1·43	0·15	1·71	1·32	0·39	–	–	–	1·86	2·38	0·38
3	2·55	2·14	0·22	2·57	1·97	0·59	–	–	–	2·79	3·58	0·56
4	3·40	2·86	0·29	3·43	2·63	0·79	–	–	–	3·72	4·77	0·75
5	4·26	3·57	0·36	4·29	3·29	0·98	–	–	–	4·64	5·96	0·94
	Locust Beans (pods)						Peas			Wheat		
1	0·85	0·71	0·04	–	–	–	0·86	0·69	0·18	0·87	0·72	0·10
2	1·70	1·43	0·07	–	–	–	1·72	1·38	0·36	1·73	1·43	0·19
3	2·55	2·14	0·11	–	–	–	2·58	2·07	0·55	2·60	2·15	0·29
4	3·40	2·86	0·14	–	–	–	3·44	2·76	0·73	3·46	2·86	0·38
5	4·25	3·57	0·18	–	–	–	4·30	3·45	0·91	4·33	3·58	0·48
	Oats			Cotton Cake (Bombay)			Cotton Cake (Egyptian)			Cotton Cake (decorticated)		
1	0·87	0·60	0·08	0·88	0·40	0·15	0·88	0·42	0·17	0·90	0·68	0·35
2	1·73	1·19	0·15	1·75	0·80	0·30	1·76	0·83	0·35	1·80	1·37	0·69
3	2·60	1·78	0·23	2·63	1·20	0·46	2·64	1·25	0·52	2·71	2·05	1·04
4	3·46	2·38	0·30	3·51	1·60	0·61	3·52	1·66	0·69	3·61	2·74	1·38
5	4·33	2·98	0·38	4·38	2·00	0·76	4·40	2·08	0·86	4·51	3·42	1·73
	Cotton Seed Meal			Coconut Cake			Ground-nut Cake (decorticated)			Ground-nut Cake (undecorticated)		
1	0·91	0·70	0·37	0·89	0·77	0·16	0·90	0·73	0·41	0·90	0·57	0·27
2	1·83	1·40	0·74	1·77	1·54	0·33	1·79	1·46	0·83	1·79	1·14	0·54
3	2·74	2·10	1·10	2·66	2·30	0·49	2·69	2·19	1·24	2·69	1·70	0·82
4	3·65	2·80	1·47	3·54	3·07	0·66	3·59	2·92	1·65	3·59	2·27	1·09
5	4·56	3·50	1·84	4·43	3·84	0·82	4·48	3·65	2·06	4·48	2·84	1·36
				Linseed Cake (English)			Palm Kernel Cake (English made)			Palm Kernel Meal (extracted)		
1	–	–	–	0·89	0·74	0·25	0·89	0·73	0·17	0·90	0·71	0·17
2	–	–	–	1·78	1·48	0·49	1·78	1·46	0·34	1·80	1·43	0·33
3	–	–	–	2·66	2·22	0·74	2·67	2·20	0·51	2·70	2·14	0·50
4	–	–	–	3·55	2·96	0·98	3·56	2·93	0·68	3·60	2·85	0·66
5	–	–	–	4·44	3·70	1·23	4·45	3·66	0·85	4·50	3·56	0·83
	Soya-bean Cake			Soya-bean Meal (extracted)			Fish Meal (White)			Yeast (Dried)		
1	0·86	0·69	0·37	0·89	0·64	0·38	0·87	0·59	0·53	0·96	0·67	0·41
2	1·71	1·38	0·74	1·77	1·28	0·77	1·74	1·18	1·06	1·91	1·34	0·82
3	2·56	2·07	1·11	2·66	1·92	1·15	2·61	1·77	1·59	2·87	2·02	1·22
4	3·42	2·76	1·48	3·55	2·56	1·53	3·48	2·36	2·12	3·83	2·69	1·63
5	4·28	3·44	1·84	4·44	3·20	1·92	4·35	2·94	2·65	4·78	3·36	2·04

RATION READY RECKONER. B. CONCENTRATED FOODS—continued

lb.	Dry Matter (lb.)	Starch Equivalent (lb.)	Protein Equivalent (lb.)	Dry Matter (lb.)	Starch Equivalent (lb.)	Protein Equivalent (lb.)	Dry Matter (lb.)	Starch Equivalent (lb.)	Protein Equivalent (lb.)	Dry Matter (lb.)	Starch Equivalent (lb.)	Protein Equivalent (lb.)
	Brewers' Grains (dry)			Distillers' Grains (dry)			Malt Culms			Maize (flaked)		
1	0·90	0·48	0·13	0·92	0·57	0·19	0·90	0·43	0·16	0·89	0·84	0·09
2	1·79	0·97	0·25	1·84	1·14	0·38	1·80	0·87	0·32	1·78	1·68	0·18
3	2·69	1·45	0·38	2·76	1·72	0·58	2·70	1·30	0·48	2·67	2·52	0·28
4	3·59	1·93	0·50	3·68	2·29	0·77	3·60	1·74	0·64	3·56	3·36	0·37
5	4·48	2·42	0·63	4·60	2·86	0·96	4·50	2·17	0·80	4·45	4·20	0·46
	Maize Germ Meal			Maize Gluten Feed			Middlings (fine)			Middlings (coarse)		
1	0·89	0·84	0·10	0·90	0·76	0·19	0·87	0·82	0·07	0·87	0·68	0·13
2	1·78	1·69	0·21	1·79	1·51	0·38	1·73	1·63	0·15	1·74	1·36	0·26
3	2·68	2·53	0·31	2·69	2·27	0·58	2·60	2·45	0·22	2·61	2·04	0·39
4	3·57	3·37	0·41	3·58	3·02	0·77	3·47	3·27	0·30	3·48	2·72	0·52
5	4·46	4·22	0·52	4·48	3·78	0·96	4·34	4·09	0·37	4·35	3·40	0·66
	Wheat Bran			Rice pollard						Treacle or Molasses		
1	0·87	0·60	0·12	0·91	0·72	0·07	–	–	–	0·75	0·52	0·01
2	1·74	1·19	0·24	1·82	1·45	0·14	–	–	–	1·49	1·03	0·02
3	2·61	1·79	0·35	2·73	2·17	0·21	–	–	–	2·24	1·55	0·04
4	3·48	2·38	0·47	3·64	2·89	0·28	–	–	–	2·99	2·06	0·05
5	4·35	2·98	0·59	4·56	3·62	0·36	–	–	–	3·74	2·58	0·05

N.B.—The blank spaces are left for the convenience of readers who may wish to enter the revelant data for foods not included in the reckoner.

TABLE IV

READY RECKONER*

SHOWING FOR DIFFERENT PERIODS OF TIME, THE QUANTITY WHICH CAN BE FED PER DAY WHEN THE AMOUNT AVAILABLE PER HEAD IS FIXED, OR THE AMOUNT REQUIRED PER HEAD WHEN THE DAILY QUANTITY IS FIXED.

Quantity per head				3 months = 90 days	4 months = 120 days	5 months = 150 days	6 months = 180 days	200 days	7 months = 210 days
Tons	cwt.	qtr.	lb.	lb.	lb.	lb.	lb.	lb.	lb.
		3	6	1·00	0·75	0·60	0·50	0·45	0·43
	1	0	8	1·33	1·00	0·80	0·67	0·60	0·57
	1	1	10	1·66	1·25	1·00	0·83	0·75	0·71
	1	2	2	2·00	1·50	1·20	1·00	0·90	0·86
	1	3	4	2·22	1·67	1·33	1·11	1·00	0·95
	1	3	14	2·33	1·75	1·40	1·17	1·05	1·00
	2	0	1	2·50	1·87	1·50	1·25	1·14	1·07
	2	1	18	3·00	2·25	1·80	1·50	1·35	1·28
	2	2	20	3·33	2·50	2·00	1·66	1·50	1·43
	2	3	7	3·70	2·62	2·10	1·85	1·57	1·50
	5	0	0	6·20	4·60	3·70	3·10	2·80	2·70
	6	0	0	7·50	5·60	4·50	3·70	3·30	3·20
	7	0	0	8·70	6·50	5·20	4·30	3·90	3·70
	8	0	0	10·00	7·40	6·00	5·00	4·40	4·30
	9	0	0	11·20	8·40	6·70	5·60	5·00	4·80
	10	0	0	12·40	9·30	7·50	6·20	5·60	5·30
1	0	0	0	25·00	18·70	15·00	12·40	11·20	10·70
2	0	0	0	50·00	37·00	30·00	25·00	23·00	21·00
4	0	0	0	100·00	74·00	60·00	50·00	46·00	42·00
8	0	0	0	200·00	148·00	120·00	100·00	92·00	84·00

0·25 = ¼ lb. 0·50 = ½ lb. 0·75 = ¾ lb.

* Based on a similar table published in the Ministry of Agriculture's Bulletin No. 42, and here reproduced by permission of the Controller, H.M. Stationery Office.

TABLE V

READY RECKONER*

PRICES PER TON AND EQUIVALENT PRICES PER LB., PER STONE (14 lb.) AND PER CWT.

Per ton	Per lb.	Per stone	Per cwt.	Per ton	Per lb.	Per stone	Per cwt.
s. d.	d.	s. d.	s. d.	£ s. d.	d.	s. d.	£ s. d.
2 6	·013	–	1½	6 0 0	·64	9	6 0
3 4	·018	¼	2	7 0 0	·75	10½	7 0
5 0	·027	¼	3	8 0 0	·86	1 0	8 0
6 8	·036	½	4	9 0 0	·96	1 1½	9 0
7 6	·040	½	4½	10 0 0	1·07	1 3	10 0
10 0	·053	¾	6	11 0 0	1·18	1 4½	11 0
12 6	·067	¾	7½	12 0 0	1·29	1 6	12 0
13 4	·071	1	8	13 0 0	1·39	1 7½	13 0
15 0	·080	1	9	14 0 0	1·50	1 9	14 0
17 6	·094	1¼	10½	15 0 0	1·61	1 10½	15 0
20 0	·107	1½	1 0	16 0 0	1·71	2 0	16 0
40 0	·214	3	2 0	17 0 0	1·82	2 1½	17 0
60 0	·321	4½	3 0	18 0 0	1·93	2 3	18 0
80 0	·429	6	4 0	19 0 0	2·04	2 4½	19 0
100 0	·536	7½	5 0	20 0 0	2·14	2 6	1 0 0

·25d. = ¼d. ·50d. = ½d. ·75d. = ¾d.

Example. A ton of oats costs £13 15s. 0d. What is the price per lb., per stone, per cwt.

£13 15 0 = £13 + 15/-.

From table. Price per lb. = 1·39 + ·080 = 1·47 = 1½d.

	s. d.		d.		s. d.	
,, ,, stone =	1 7½	+	1d.	=	1 8½	
,, ,, cwt. =	13 0	+	9d.	=	13 9	

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TABLE VI

READY RECKONER*

PRICES PER TON OF GRAIN WHEN QUOTATION IS GIVEN IN PRICE PER QUARTER

Price per qtr.	Price per ton: per qtr. of 304 lb.	per qtr. of 320 lb.	per qtr. of 336 lb.	per qtr. of 400 lb.	per qtr. of 448 lb.	per qtr. of 480 lb.	per qtr. of 504 lb.
£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.
1	7¼	7	6¾	5½	5	4¾	4½
2	1 2¾	1 2	1 1¼	11¼	10	9½	9
4	2 5½	2 4	2 2½	1 10½	1 8	1 6¾	1 5¾
8	4 11	4 8	4 5¼	3 9	3 4	3 1¼	2 11½
1 0	7 4½	7 0	6 8	5 7¼	5 0	4 8	4 5¼
2 0	14 9	14 0	13 4	11 2½	10 0	9 4	8 10½
4 0	1 9 5½	1 8 0	1 6 8	1 2 5	1 0 0	18 8	17 9¼
8 0	2 18 11¼	2 16 0	2 13 4	2 4 10	2 0 0	1 17 4	1 15 6½
16 0	5 17 10½	5 12 0	5 6 8	4 9 7	4 0 0	3 14 8	3 11 1
1 0 0	7 7 4	7 0 0	6 13 4	5 12 0	5 0 0	4 13 4	4 8 10½
2 0 0	14 14 8½	14 0 0	13 6 8	11 4 0	10 0 0	9 6 8	8 17 9
3 0 0	22 2 0	21 0 0	20 0 0	16 16 0	15 0 0	14 0 0	13 6 7½

Example. What is the price of oats per ton when the price per quarter of 336 lbs. is £2 1s. 6d.

£2 1s. 6d. = £2 + 1s. + 4d. + 2d.

From table price per ton = £13 6s. 8d. + 6s. 8d. + 2s. 2½d. + 1s. 1¼d.
= £13 16s. 7¾d.

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TABLE VII
WEIGHT OF FOODS BY MEASURE *

FOOD	Weight per bushel	FOOD	Weight per bushel
1. *Roots*	lb.	5. *Oil Cakes (broken), and Meals*	lb.
Carrots (whole)	40	Coconut cake	39
Mangolds (whole)	45	Cotton cake, decorticated	45
Mangolds (sliced, fingered or pulped)	40	Cotton cake, undecorticated	40
Parsnips (whole)	45	Cotton seed meal	50
Swedes (whole)	45	Ground-nut cake, decorticated	46
Potatoes	49	Ground-nut cake, undecorticated	40
Swedes (sliced, fingered or pulped)	40	Ground-nut meal, decorticated	54
Turnips (whole)	42	Ground-nut meal, undecorticated, extracted	40
Turnips (sliced, fingered or pulped)	36	Linseed cake	44
2. *Green Foods*		Palm kernel cake	36
Silage, mixed cereal and vetch	16	Palm kernel meal, extracted	30
Silage, grass	26	Sesame cake	39
Silage, from other green foods	20	Soya-bean cake	45
3. *Hay and Straw*		Soya-bean meal	50
Hay, chaffed	5	Sunflower cake	39
Oat chaff	4	Sunflower meal	30
Oat straw, chaffed	5	Proprietary compound cakes	42
4. *Grains and Seeds*		Proprietary compound meals	43
Barley	55	6. *Manufactured and By-products*	
Beans	64	Barley meal	30
Buckwheat	50	Bean meal	50
Butterbeans	52	Bran	16
Dari	60	Brewers' grains, wet	40
Gram	60	Brewers' grains, dried	22
Lentils	62	Distillers' grains, dried	20
Linseed	52	Fish meal	48
Maize	60	Gram meal	49
Millet	60	Locust bean (pod) meal	48
Oats	42	Maize, flaked	20
Peas	64	Maize germ meal	39
Rye	54	Maize gluten feed	42
Wheat	62	Maize meal or Indian meal	47
		Oats (crushed)	25
		Malt culms	17
		Meat meal	50
		Middlings or Weatings	30
		Rice meal	40
		Sugar-beet pulp, dried	16
		Wheat meal	44
		Yeast, dried	53

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TABLE VIII

WEIGHT OF SOME POULTRY FOODS BY MEASURE

FOOD	Weight per pint	FOOD	Weight per pint
	oz.		oz.
Alfalfa or lucerne meal ..	7·6	Millet seed	15·3
Barley	13·2	Millet seed meal	10·9
Barley meal	9·8	Milk, dried skim	11·8
Beans, cracked	12·3	Oats	10·7
Bean meal	11·8	Oats, Sussex ground ..	7·7
Biscuit meal	8·1	Peas	15·8
Blood meal	17·2	Pea meal	10·3
Buckwheat	11·3	Palm kernel meal . ..	10·9
Buckwheat meal	12·6	Rice, unhusked	11·8
Buttermilk, dried	12·6	Rice, husked	16·2
Coconut meal	9·5	Rice, polished	16·2
Cotton seed meal	12·1	Rice bran or pollard.. ..	9·8
Dari	14·2	Rye	12·5
Dari meal	11·3	Rye meal	9·2
Fish meal	13·2	Soya-bean meal, extracted ..	10·9
Grass meal	5·7	Sunflower seed meal, extracted	7·7
Groats..	14·2	Sugar-beet pulp, molassed ..	5·1
Ground-nut meal	12·3	Sugar-beet pulp, as meal ..	13·5
Hempseed	11·6	Wheat, strong varieties ..	14·5
Linseed	14·4	Wheat meal, from strong wheats	11·3
Linseed meal	10·2	Wheat, weak varieties ..	14·2
Maize	13·8	Wheat meal, from weak wheats	12·1
Maize, flaked	4·4	Wheat bran	4·9
Maize, flaked and ground ..	11·6	Wheat middlings, coarse ..	8·4
Maize gluten feed	10·0	Wheat middlings, fine .	10·9
Maize gluten meal	10·6	Whey, dried	14·1
Maize meal	11·9	Yeast, dried	13·5
Meat meal	12·6		
Cod liver oil	18·5		

INDEX

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